The impact of an in-service teacher training programme on teachers involved with computers in education.

Monteiro, Maria Cecilia Soares de Morais

THE IMPACT OF AN IN-SERVICE TEACHER TRAINING PROGRAMME ON TEACHERS INVOLVED WITH COMPUTERS IN EDUCATION

by

MARIA CECILIA SOARES DE MORAIS MONTEIRO

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FOREWORD

The research presented in this thesis is, to the best of my knowledge, original, except where due references have been made. It has not previously been submitted by me for a degree in this or any other University.

Signed

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ABSTRACT

The research concerned the conception, implementation and evaluation of an in-service programe for teachers involved with computers in education. This study was developed in the context of the MINERVA project with the aim of introducing computers in elementary and secondary schools in Portugal. The teachers involved were primary and preparatory teachers (6-12 year old students).

The research study was conducted in two major stages. In the first stage during the year of the implementaton of the programme twenty nine teachers were involved; the second stage took place in the following year when eight mathematics teachers were studied in depth.

The data was gathered by means of questionnaires, interviews ad participant observation; it also included the teachers' work during the programme and written materials developed by them.

The impact on teachers was studied in relation to three main themes: 1) Teachers' attitudes relating to the use of computers in schools both in curricular and extracurricular activities; 2) Teachers' attitudes concerning the teaching and learning process; 3) Teachers' views about their own development.

It was found that there was a relation between teachers' views about mathematics curricula (boundary and hierarchy of contents) and the level of students' participation with computers allowed in learning activities.

Teachers' development was studied for a long period of time (two years). This allowed observation of many differences among teachers and, over time, in individual teachers, regarding both their views about computers and the work they decided to develop using computers with students.

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CHAPTER 1

AIM AND BACKGROUND

1.1. AIM

This research concerns the conception, implementation and evaluation of an in-service teacher programme for teachers involved in the introduction of computers in schools in Portugual.

The particular focus of the study is the impact of this teacher training programme on teachers' attitudes towards the teaching/learning process and their pedagogical practices.

The research also studied the effects of the programme on teachers' views about:

1. the use of computers in education; and
2. their own professional development

1.2 BACKGROUND TO THE STUDY

This section gives a brief overview of Mathematics Education in Portugal, and the main objectives of the MINERVA project, which was designed to introduce computers to the Portuguese educational system. These two aspects are the context of the research of this study.

1.2.1 Mathematics Education in Portugal

In Portugal, when this study began, 22.5% of fifth and 16.5% of sixth graders at the Preparatory level (ages 10 to 12), failed at school, and 33.2% failed at the end of Primary School (Statistics Department of the Ministry of Education, 1987). One of the subjects that most contributed to this situation was generally acknowledged to be Mathematics, although there are no detailed statistics at the moment. Mathematics has proved to be an obstacle for the students and it is a subject that they usually dislike.

Mathematics was usually approached in a very formal and abstract way even for students of preparatory schools. Manipulative materials or problem solving tasks were not yet common activities within mathematics classrooms.

Most of the mathematics teachers had a teacher centred approach, and when they developed student activities, these were mainly routine exercises. The textbook was used to provide the exercises, but it was rarely studied by the students, the teacher being the only source of information.

In some Preparatory and Secondary schools there were "clubs", where students developed extracurricular activities. These activities were concerned with several subjects, such as music, photography, computers, journalism, mathematics, foreign languages, and so on. In mathematics clubs, teachers usually provided activities for students with puzzles, games and other similar materials.

When this atudy began the Portuguese government was preparing a series of reforms for the Educational System, which included a reform in the curriculum development area. One of the aims of this reform was to try to modernise the school system as well as to promote a decrease in school failure. The curricular reforms concerned the subjects themselves, the syllabus, methodological principles, and specific objectives, as well as some aspects related to school organisation. Concerning Mathematics Education, for the 10-12 years old students, the main objectives established in the new curricula were:

- To develop the capacity for using mathematics as a tool to interpret and to intervene in real life
- To develop the capacity for solving problems
- To develop the capacity of communication, critical reasoning and creativity
- To develop attitudes of autonomy and cooperation in the learning process.

Since 1990 the new curricula has been implemented with an experimental phase that lasted two years, involving a very small number of schools. In 1992 general implementation took place in schools all over the country.

The Mathematics education climate has been changing in Portugal, also due to teachers' organisations. These changes are mainly related to the Portuguese Mathematics Association, which has promoted, since 1985, national meetings and local working groups, where new ideas and pedagogical issues are discussed and teachers' experiences are shared. The use of calculators and computers in mathematics teaching has been one of the most important themes, as well as teacher education issues.

Through public pronouncements the Minister of Education has made it clear that he considers teachers to be the main agents of educational reform in the schools. In 1985 a regional network of

Higher Schools of Education, to be in charge of pre-service teachers of 3 to 12 year old students and in-service training, was implemented. However, institutionalised, continuous teacher education has no tradition in Portugal. The Ministry of Education is preparing an official document concerning in-service teacher education in the context of the reform of the Educational System.

1.2.2. Use of computers in Portuguese Schools

The national MINERVA Project was designed to promote the introduction of information technology in primary, preparatory and secondary schools . This Project had an experimental phase, from 1985 to 1989. Since 1989 it has moved into a new phase, that will last until 1993, and then all the preparatory and secondary schools and 25% of the primary schools will be involved in using these technologies.

The MINERVA project aimed to take advantage of the possibilities offered by new information technology to update school curricula and methods. It was not a new course in, for example computer literacy, or a new discipline in which students would learn about computers. It was recommended that the computer was used as a tool, fostering students' learning.

The main objectives of this project were published in the official document of the Portuguese Government (Diario da Republica nº 263 II Serie, D.L. 206/ME/ 1985/11/15). They were:

"1) The inclusion of New Information Technology in school curricula in all levels of education, except for higher education;

2) The introduction of New Information Technology as a pedagogical tool and resource;

3) The training of advisers, teachers educators and teachers for the teaching of the New Information Technology as well as for its use as a pedagogical tool and resource."

In 1985/86, the Project involved 40 schools. By 1989/90 it included 644 schools and approximately 15000 teachers, and by 1990/91 a total of 1172 schools and approximately 50000 teachers were involved (Diario da Republica, Desp. 123/SE RE/SE EBS/92). From 1991/92 to 1993/94 no more schools were included in the MINERVA Project, and it was recommended to the Nodes to deepen the work inside each school. The Universities and Higher Schools of Education constituted a network of Nodes of the Project. They were in charge of developing implementation programmes within the respective teacher training arrangements, and were responsible for the implementation of the project in their area. These institutions also supported the work that was being carried out in the schools with teachers and students. The Project began with seven nodes in 1985/86, and by 1989/90 there were twenty five nodes of the project all over the country. These nodes worked on a decentralised and independent basis. This autonomy was also established in the official document cited earlier. A National Committee for the Project was appointed by the Ministry of Education, which was concerned with evaluation and with the establishment of common general orientations both in teacher training and in the curricular use of computers.

Teachers of several disciplines were involved in this project. They worked on a voluntary basis. In the beginning of the school year, interested teachers were proposed by the school board to liaise with the CEM (MINERVA school centre). The preparatory and secondary teachers had 4/5 hours free of classes each week to attend the teacher training courses, to develop computer activities with students, and to promote some workshops for their colleagues in order to involve them in working with computers. There were 4/6 teachers in each school directly linked with the respective node of the MINERVA Project, but sometimes other teachers were encouraged to participate in computer activities and to work in the CEM, who did not themselves have any reduction of class time.

There have been mainly two kinds of teachers' reactions to the Project; some teachers seemed quite uninterested, while others expressed the desire to participate in computer activities and to receive in-service teacher training.

'Teacher educators' were invited to work on the Minerva Project and they were linked to one Node, working together with the researchers and with some teachers of the respective university or higher school of education. Some of these teachers from primary, preparatory or secondary schools, had considerable pedagogical experience and some technical knowledge, and they improved their capacities by attending special programmes organised for them (inside the Node). Most of these teachers had worked before in their schools on the Project and they had experience of computer work with students. At the beginning of the

Project, most of the teacher educators did not have any knowledge or experience about education technology.

Most of the computers used in the Project MINERVA were MS-DOS machines, some of them with a hard disk. The average number of computers was 2 or 3 in primary schools and 5 to 7 in preparatory and secondary schools.

By decision of the Ministry of Education, Project MINERVA will be evaluated during the school year of 1993/94, and it will be over at the end of this year.

1.2.3. In-Service Teacher Education for the use of computers in Portuguese schools

In-service teacher education related to the use of computers in primary, preparatory and secondary schools started with the beginning of the MINERVA Project. As the several universities and higher schools of education worked on an independent basis, teacher training had different characteristics in different places. The Nodes had different ways of working with teachers, giving different approaches to the pedagogical use of computers. However since 1986 there have been some national meetings, which have provided for the sharing of experiences and ideas, as well for discussion concerning teacher training. Whether the emphasis should be on learning technical aspects or on the pedagogical issues raised by the kind of software used, or on the kind of use of computers in the classroom, are the main questions which have been discussed by some Nodes of the Project. The need for elaborate training programmes for teachers which take into consideration the dimension of the computer in education is being pursued by teacher training institutions.

Most of the work already carried out with students was connected with extracurricular activities. However there had been some sporadic attempts to introduce computers into the classroom. But computers may be used to fit into a traditional way of teaching. They can be used just as one more pedagogical method at the service of transmission style teaching, and reinforcing the passivity of the student and therefore also reinforcing his scant interest in school work.

Traditionally, in Portugal, there have not been co-operative projects between schools and universities or other higher schools of education institutions. The MINERVA Project had the potential for providing the development of projects on a co-operative basis, which is one way to train teachers in the pedagogical uses of computers related to the school reality. Since 1989/90, there have been the CALs (Local Support Centres) linked to each Node. These have attempted a decentralised method of training, supporting teachers who have technical problems, or helping them in the development of their projects. Also the work undertaken by these teacher centres varies from Node to Node; in most of them they are just beginning their activities.

The author of this study is a mathematics teacher who has worked since 1985 in the Higher School of Education in Lisbon, and who was also the person responsible for the Node of the MINERVA Project at this School. As stated in the aim at the begining of this chapter, this study evaluates the impact of this programme on a group of teachers.

1.3. PLAN OF THE THESIS

In chapter two, various themes will be reviewed. Section one presents some literature related to active learning, and a constructivist approach to learning theory is described. Section two gives an overview of the introduction of computers in education and the educational consequences, both in students' learning and teachers' practices. Section three refers to literature concerning teacher training, presenting some aspects related to teachers' professional development. At the end of this chapter another section presents the implications of the literature for the teacher training programme of the study.

Chapter three describes the teacher training programme and its objectives, and characterises the different phases of the programme, and the different modes of the work developed with teachers.

Chapter four concerns the methodology followed in the investigation, including a brief description of the teachers involved, and the study instruments, as well as the relationship between the methods used and the literature.

Chapter five concerns the teachers' perceptions at the beginning of the programme, and their first reactions to the programme in terms of their opinions as well as concerning their practical work with students during the development of the course.

Chapter six describes, analyses and discusses the work developed by the eight mathematics teachers during the second year of the research, and their attitudes concerning the use of computers in education.

Chapter seven studies teacher development from the point of view of the teachers involved in the in-service teacher training programme of this study, as well as the teachers' evaluation of the programme.

Finally, chapter eight discusses the conclusions, and recommendations of the study.

CHAPTER 2

REVIEW OF LITERATURE

2.1. INTRODUCTION

This chapter concerns the review of literature which is related to the following aspects:

1. **Active Learning:** This section analyses different views of active learning, develops the method of projects as one pedagogical approach in which learners are active agents of their learning process, and summarises some aspects of the constructivism approach.

2. **Use of Computers in Education:** This part describes different uses of computers in education as well as analysing some aspects concerning the use of computers as a pedagogical tool in the learning process.

3. **Teacher Development:** The initial part of this section is concerned with factors which influence or can contribute to teachers' professional development, as well as reviewing some authors who have written about stages of teachers' development. Secondly an analysis of different types of teacher education models is done with respect to two main issues: the identification of teachers' needs and the most worthwhile knowledge for teachers. Finally the implications of both computers in teaching and teacher education for the use of computers in schools is

studied through some examples of teacher training experiments.

Some implications of the literature in the design of the in-service teacher training programme of this study are referred to in the end of this chapter.

2.2. ACTIVE LEARNING

The term active learning is used with several meanings and it is related to different educational practices. Active learning is also interpreted by teachers in a very global way, contrasting with the teacher centred model, where the student has a passive attitude listening to the teacher explaining the same thing for the whole class. Traditional methods are mainly concerned with the transmission of knowledge and skills from "by the expert-teacher to the apprentice- pupil" (Brandes and Ginnis, 1986, p. 2), in which "students passively absorb information, storing it in easily retrievable fragments as a result of repeated practice and reinforcement" (NCTM, 1989, p. 10). However there are those who consider that "no learning is entirely passive" (Beswick, 1987, p. 19), even when the student is listening the teacher lecturing, if he is learning something. According to Beswick also, students "who are apparently very busy in activity projects may be totally uninterested and learning little" (p. 20). To this author active learning is directly related to students' engagement in projects which have meaning to them, and he states that:

"Open-ended work gives the student a measure of choice in what is being done, and how, by what means and in what direction. It is a major factor in the development of research skills, creative exploration and the ability to learn independently and 'make one's own meaning'" (p. 21).

Edwards and Mercer (1987) refer to the Plowden Report (1967) where it is stated that "the child is the agent of his or her own learning" (p. 37), explaining that:

"Verbal exposition, in advance of understanding based on experience, may be an obstacle to learning, and children's knowledge of the right words may conceal from teachers their lack of understanding",(quoted by Edwards and Mercer, p. 37).

One characteristic of active learning is the learner's autonomy, "where students take greater responsibility for their own learning" (Boud, 1988, p. 22). Boud defines three main classes of teaching approaches in an active learning context:

"1)**The individual-centred approach**: This is characterised by a focus on individual learners and their needs. Teachers, co-learners and other resources for learning are enlisted to facilitate the attainment of the goals of the individual as defined by the individual. Groups of learners may provide general support but they do not generally have a specific role or commitment to any project other than their own.

2) **The group-centred approach**: this cluster of approaches is characterised by a focus on the needs of a particular group of learners and a strong commitment to group learning and group processes. Individuals pursue their own learning needs within the context of the group, referring to others for support and feedback and for validation of the enterprise. Much learning occurs from interactions between group members. There is an emphasis on democratic decision-making and the consideration of different points of view within the group.

3)**The project-centred approach:** In this group of approaches the particular learning project and its outcomes are often as important or more important than the individuals or the group which is working on it. The project gives meaning to and characterises the enterprise....Students exercise considerable initiative and engage in individual learning in association with the problem, but it is the problem itself which ultimately defines the area of learning" (p. 27-28).

The concept of autonomy in learning is also focused on by Knapper (1988), who considers that in the modern society students must develop "the ability to learn from and through life", especially "in a world experiencing rapid and profound change",(p. 92). Knapper adds that:

"If people outside the educational institutions do, by force of the circumstances, act more or less as autonomous learners, and there is evidence to suggest that they do, then the activities within educational institutions should be structured in such a way that they prepare students for learning after school(lifelong learning) and assist them to develop the skills they will need in order to exercise responsibility for learning effectively (p. 92).

Authors who advocate learner participation in the learning process, emphasise different aspects, such as the cognitive aspect (Piaget), affective aspect (Rogers) and social aspect (Dewey and Vygotsky). Also Bernstein (1977) has studied the power of teacher and student in class relationship, analysing underlying principles which shape curriculum and pedagogy. According to Bernstein, both curricula (collection or integrated) and pedagogy (strong and weak frame), define the degree of control teacher and student posses over the selection, organization and pacing of the knowledge transmission.

In the 1960s, Carl Rogers introduced the designation "Student Centred Learning" claiming that the ownership of learning is with the student. This idea is summarised in his very well known statement "I know I cannot teach anyone anything, I can only provide an environment in which he can learn" (1965, p. 389).

According to Rogers (1969), in an active learning context:

> "A student develops her own programme of learning, alone or in cooperation with others. Exploring one's own interests, facing this wealth of resources, the student makes the choices as to her own learning direction and carries the responsibility for the consequences of those choices" (p. 188).

Watts and Bentley (1987) write about the affective aspects and the facilitating aspects of teacher behaviour within an educative environment. These ideas concern the "non-threatening learning environment", where the students " are encouraged to make explicit their existing ideas" (p. 132).

Active learning is an old concept. The ideas of Dewey on education refer to the importance of learning through action and personal experience, emphasising the social aspects and the students' interests in knowledge acquisition. The conception of learning through experience, the acquisition of skills and techniques as means of attaining personal and significant ends and the cooperative work within groups of students, and between teacher and students, are fundamental in Dewey's philosophy of education. For example, Peters (1977), considers that Dewey's philosophy of education, "was an attempt to introduce the problem solving, do-it-yourself method of the learning,...the close link between learning and living and the sense of contributing to a social whole permeated by shared experiences" (p. 102).

Active learning including the social aspect through interaction among students and between teacher and students was also focused on by Vygotsky (1962), who, studying the development of children's thinking, stressed the importance of the use of negotiated meaning as a mean of concept formation. For him, verbal communication between children and adults is an important factor in the learning situation. Vygotsky stresses the difference between a word in a lecture and its socially negotiated meaning:

> "Many words, therefore, have in part the same meaning to the child's habitual surroundings. The child's and the adult's meanings of a word often "meet", as it were, in the same concrete object, and this suffices to ensure mutual understanding" (p. 60).

Edwards and Mercer (1989), taking inspiration from Vygotsky, explain the concept of what they call the "context" and the "continuity". The term context refers to "everything that the participants in a conversation know and understand over and above that which is explicit in what they say, that contributes to how they make sense of what is said" (p. 63). Continuity is related to shared memories, intentions and understandings. These two aspects should be presented during an educational process where students and teachers "act and talk together to some common purpose" (Edwards and Mercer, p. 166).

Newman, Griffin and Cole (1989) analyse both students' and teachers' roles as well as the teacher - child negotiation in the learning process. They studied the teacher-student instructional interaction which provides a way to study active learning in a social context, trying to define what should be the teacher's role. Their work is based on Vygotsky's concept the "Zone of proximal development (ZPD)", which provides an approach to studying children's performance of a task. According to these authors:

> "Instead of giving the children a task and measuring how well they do or how badly they fail, one can give the children the task and observe how much and what kind of help they need in order to complete the task successfully" (p. 77).

The level of teachers' intervention in order to help students to solve a problem or to accomplish a task is related to the children progress in doing it. As Newman, Griffin and Cole say "the teacher necessarily takes every opportunity to teach rather than waiting for children to fail at the task" (p. 15). They state that:

> "We have seen that the process of instruction cannot be reduced to direct transmission of knowledge, nor are creative learning processes necessarily entirely internal to individuals" (p. 112).

The use of concrete and manipulative materials was advocated by some early educators such as Montessori, Decroly, and Pestalozi. Also both Bruner and Piaget put emphasis on the importance of material actions and problem-solving in learning in order to develop abstract thinking. Bruner advances three ways to represent a domain of knowledge: by a set of actions that implies the use of concrete materials ("enactive" representation), the "iconic" form of representation, including graphics, pictures and drawings, and the "symbolic" representation, through sentences or other symbolic propositions, relating statements to each other.

> "Bruner attaches great importance to processes of learning and claims that the best way to learn a subject is by doing it rather than being told about it. Thus learning by doing, discovering and inquiring is inextricably linked with his understanding of intrinsic motivation. One way in which teachers can stimulate thought and encourage pupils to explore further, is to work with conjectures and hypotheses, prompting pupils to suggest what might occur under certain circumstances or what might have happened, given different conditions" (Downey and Kelly, 1986 p. 77).

In mathematics education active learning is often viewed as a problem-solving approach, where it is not necessary to include a practical activity but must include mental activity. The Cockcroft Report (1982), recommends the adoption of problem-solving, discussions and investigational work in mathematics teaching. Instruction should vary and include opportunities for:

> "Exposition by the teacher;
> Discussion between teacher and pupils and between pupils themselves;
> Appropriate practical work;
> Consolidation and practice of fundamental skills and routines;
> Problem solving, including the application of mathematics to everyday situations;
> Investigational work" (p. 71).

The process that students use in solving problems is considered by Polya (1951) to be more important than just giving an answer. According to this author, to use problem solving activities to stimulate independent work, the teacher should have a very important role in guiding students' reasoning through the heuristical method. Polya defends this method, saying that:

> "Modern heuristic endeavours to understand the process of solving problems, especially the mental operations typically useful in this process....Experience in solving problems and experience in watching other people solving problems must be the basis on which heuristic is built" (p. 129-130).

Kilpatrick (1985), refers to Polya's work, saying that for this author the first principle of teaching is what he terms "active learning", where the teacher's role is to provide students' activity, as it is summarised in this sentence:

> "Let the students discover by themselves as much as feasible under the given circumstances....What the teacher says in the classroom is not important, but what the students think is a thousand times more important. The ideas should be born in the students' mind and the teacher should act only as midwife" (Polya 1981, quoted by Kilpatrick, p. 12).

In summary, concepts such as autonomy, learners' engagement in projects, and the use of problem solving situations are related to active learning. The teacher's role of providing educational contexts where students can interact and communicate is a fundamental aspect of a student centred pedagogy.

2.2.1 The Project Method

The project method comes from Dewey's ideas on education, which were further developed by kilpatrick, W. H. (1951). Dewey theorised and developed some of the ideas of Rousseau regarding disciplinary barriers, and of Pestalozzi, concerning education centred on the interests of students. In the project method students encounter a problem, face a new situation or express the need to solve some task or acquire new knowledge, enabling the development of content knowledge of school subject matter.

Traditional education curricula are conceived in subjects logically organised into series of facts, ideas, propositions and theories. For Dewey, almost a century ago, nothing was more illogical and inefficient than presenting knowledge to students in this way.

Dewey (1916, 1938) stressed the importance of research, scientific consciousness and rigour of thought to reach the truth. He very often talked about experience and his last books are dedicated to the description of what he thinks about the role of "learning by doing". He goes further stating that the role of the school is not just to provide the students with means to become adapted to society; it is to provide the students with means for them to change the society into a better one. Therefore education must promote simultaneously creativeness and stability, individuality and social awareness.

Based on the theories of Dewey, Kilpatrick, (1951) further developed the Method of Projects, which includes the problem method as a special case. This author asserts that we only learn what is significant for us and that interests pursued create new interests. Intrinsic motivation is a very important feature in the project work methodology, as Kilpatrick (1951) states:

> "When the new interest has sufficiently taken hold, appropriate action may be expected. If knowledge or new techniques are needed, the interest supplies the drive to go after them" (p. 276).

Two main ideas underly the method of projects: the purpose of an activity, and social and moral education through the development of a shared project. An earlier writing of Kilpatrick (1918) considers that "the purposeful act is the typical unit of the worthy life" (p. 322), and "if the purposeful act thus makes of education life itself, could we reasoning in advance expect to find a better preparation for later life than practice in living now?" (p. 323). Later on Kilpatrick (1951) develops this idea relating to the active presence of purpose in the learner:

> "...Purpose in the degree that it is present and felt, permits a higher degree of efficiency of action than otherwise would be possible; but it also means that desirable results will be effected in the degree that purposes are critically chosen and intelligently directed" (p. 254).
>
> "The purposeful activity brings learning by giving increase of seen relationships among the factors considered" (p. 256).

The second idea focuses on personal purpose related to its social meaning and on the ethical elements of social behaviour. This aspect is related to the choice of the method of teaching. Dewey and Kilpatrick consider that teachers and the act of teaching influence the character of the students. If we want students to become democratic we must have democratic attitudes by making them used to democratic situations in school. Equally if we have as an educational goal to develop students' creativity we should provide them with creative initiatives. Kilpatrick (1951) distinguished between "broad problem of method" and the "narrow problem of method", saying that the latter is "concerned solely with the subject to be taught" (p.285). He explains the broad problem of method:

> "It is concerned with many values at stake - subject matter values, attitudes and character being built, effects in democratic living, community values, and all other matters inherent in a particular situation" (p. 285).

In the project method the role of the teacher is to help the learners:

> "i) To initiate the activity (to form or choose the purpose; ii) to plan how to carry the activity forward; iii) to execute the plan; iv) to evaluate progress during the activity and the result at the end; v) encourage the learners to think up and note suggestions or new leads for other and further work; vi) help to formulate these suggestions both for clarification of thinking and later recall and possible use; vii) help pupils criticise their thinking en route or at close, as may seem wise; and finally viii) look back over the whole process to pick up and fix important kinds of learning involved as well as draw lessons for the future from both successes and failures" (p. 307).

More recent educators have both defended and implemented the method of project approach. According to Bothmer (1980):

> "The educational aim of project-method learning is to equip the student with the ability to work independently, i. e. without being alienated. This educational aim must not be conceived of as something purpose-connected, but as a process. This kind of work is characterised by a reflective, creative consciousness" (p. 125).

Fried-Booth (1986) developed a work project for language learning. This author considers project work as an extension of student-centred activities, since the student discusses and negotiates the project with the teacher, and student activities are extended beyond the classroom. Defending project work in a language teaching programme this author states that:

> "A project moves through three stages: beginning in the classroom, moving out into the world, and returning to the classroom. At each of these three stages, the teacher will be working with the students, not directing them but acting as counsellor and consultant - and, in this way, enabling them to take a project of their own devising out of the classroom into the world" (p.6).

In this kind of learning approach, "the students must be able to co-operate not only with each other but also with the teacher" (Fried-Booth, p. 9). Dewey also defends "education as a cooperative enterprise in which teachers and students participate democratically,...making the educative process a genuine sharing" (in Dewey on Education 1959 p. 130).

2.2.2. Constructivism

Constructivism is a psychological theory of learning, now accepted in the educational field which underlies the active learning approach. Piaget, who first proposed the personal construction of knowledge, studied it through the hierarchical stages of cognitive development. He was the most important researcher who stressed the interdependence between action and thought, defending the pupil's involvement which acting upon objects for developing the necessary intellectual structures. Piaget's study of developmental stages gave importance to student activity together with a rather lesser emphasis on the social dimension in learning, inasmuch they contribute to accelerating the transition to the next stage. As Wertsch, Minick and Arns (1984) note:

> "The most important individualistic theory in modern development cognitive psychology is that of Piaget. He examined social activity solely from the perspective of how it influences the individual's development" (p. 152).

Based on Piaget' writings, Sinclair (1987) states that "the essential way of knowing the real world is not directly through our senses, but first and foremost through our actions" (p. 28). Sinclair gives her interpretation of what "action" means in this context:

> " Action has to be understood in the following way: all behaviour by which we bring about a change in the world around us or by which we change our own situation in relation to the world. In other words ,it is the behaviour that changes the knower-known relationship" (p. 28).

Following Sinclair's idea that the changes the subject introduces in the knower - known relationship are the origins of new knowledge, the subject's experiences are interpreted and followed by the construction of "theories (in action or thought)" (p. 29), giving to the subject a sense to these experiences.

Also Pope (1985) has the opinion that "in our existing constructions our appreciations of the external is always represented in the light of our current theorising" (p. 10). According to Nystedt and Magnusson (1982), cited by Pope (1985):

> "It is fundamental to the constructivist' s view that the environment can never be directly known but that conception determines perception. We know reality only by acting upon it. This means that knowledge is neither

a copy nor a mirror of reality, but the forms and content of knowledge are constructed by the one who experiences it. The active interaction between the individual and the environment is mediated by the cognitive structures of the individual. What we learn in interaction with the environment is dependent upon our own structuring of those experiences. Thus according to this view, man does not merely respond to the environment, he construes it" (p. 11).

According to Forman and Pufall (1988):

"Central to constructivism is the assumption that to know is to continually reconstruct, to move from a more to a less intuitive state, or from intuitive nonanalytical understanding to explicit formal understanding. In short, knowing is always intuitive to some extend or in some way" (p. 240).

These authors consider that constructivism embodies three properties: epistemic conflict that is an individual construction, a new way of thinking about the reality; self-reflection that means to become explicit, "construct or transform our way of representing reality" (p. 236); and self-regulation, that is the developmental restructuring of thought. "Through our thinking about our practical and conceptual actions, these actions can be restructured to a 'higher' level of knowing" (p. 236).

A radical form of constructivism, is advocated by Von Glasersfeld (1988), who considers that reality is out of reach, which means that knowledge is always a subjective construction. Also Kilpatrick, J. (1987), states that "the only reality we can know is the reality of our experience", and he mentions two principles, from a radical constructivism point of view:

> 1. Knowledge is actively constructed by the cognizing subject, not passively received from the environment.
> 2. Coming to know is an adaptive process that organises one's experiential world; it does not discover an independent, pre-existing world outside the mind of the learner (p. 7).

"As a theory of knowledge acquisition, constructivism is not a theory of teaching and instruction" (Kilpatrick, J. 1987, p.11), however this theory has implications for instructional procedures. Kilpatrick refers to Von Glasersfeld (1983), who identifies five consequences for educational practice:

> "(a)Teaching (using procedures that aim at generating understanding) becomes sharply distinguished from training (using procedures that aim at repetitive behaviour); (b)processes inferred as inside the students' head become more interesting than overt behaviour; (c) linguistic communication becomes a process for guiding a student's learning, not a process for transferring knowledge; (d) students' deviations from the teacher' s expectations become means for understanding their efforts to understand; and (e) teaching interviews become attempts not only to infer cognitive structures but also to modify them" (p. 12).

Related to the aspect of independence of students in the learning process, Pope (1985) notes that "learners may need to change the goggles they wear via-a-vis their expectations regarding their role in the process of teaching and learning if they are to move from a dependent to an independent and self-organised learner", (p. 9).

Social constructivism emphasises the importance of social aspects in learning acquisition from a constructivist point of view. This theory is defended by those who consider the importance of social interaction in new cognitive developments (e.g. Doise and Mugny, (1984), Watts and Bentley (1987), and Newman, Griffin and Cole (1989)). Each individual must reconstruct knowledge, but "of course not necessarily alone, since everybody needs help of other people" (Papert, 1987 p. 14). Rogoff (1984) argues that to understand cognitive development it is essential to attend to the role played by the context of cognitive activity, defending the notion that intellectual activity depends on the social context:

> "Thinking is intricately interwoven of their activity with the context of the problem to be solved. The context includes the problem's physical and conceptual structure as well as the purpose of the activity and the social milieu in which it is embedded" (p.2)

Vygotsky's approach also concerns development of knowledge by the social interaction between teacher and student, "what gives an important role to the teacher and helps to account for the variability in the process and its outcomes" (Newman and others 1989, p. 74).

The importance of social interaction in students' learning is also focused on by Bruner (1986) and by mathematics educators (e.g. Yackel and others, NCTM, 1990):

> "When children are given opportunities to talk about their mathematical understandings, problems of genuine communication arise. These problems, as well as the mathematical tasks themselves, constitute occasions for learning mathematics... They develop mathematical concepts as they engage in mathematical activity, including trying to make sense of methods and explanations they see or hear from others" (Yackel and others, p. 12-13).

Discussing teacher-student interaction these authors hold that "it is the responsibility of the teacher to try to figure out what the child means and, if necessary, to assist the child in verbalising this meaning" (p. 16).

Concerning social constructivism Doise and Mugny (1984) say that a social psychology of cognitive development cannot exclude the study of the phenomena of learning by modelling:

> "Viewing correct models also contributes to learning, but this contribution depends on the extent to which the model gives rise to sociocognitive conflict. To be effective, the model must introduce opposing centrations and at the same time offer to the thus confronted child important elements for the reorganisation of his ideas" (p. 29).

Dealing with cognitive change, Newman, Griffin, and Cole (1989) consider that it involves a "dialectical interaction between the social word and the changing individual", where "the individual is not the most useful unit of analysis" (p. 59). Without denying the individual these authors stress the importance of student teacher interactions within a social context:

> "The children's actions can function within two different understandings of the significance of the task: the child's and the teacher's. Both are constrained by socio historical understandings of the activity setting in which they are interacting" (p. 63).

These different understandings of the same task do not mean that the communication between the two participants is not successful, but it fosters the appropriation process, and "makes clear that the child's role may be reorganised during the course of interaction as it becomes more and more under the control of the teacher's interpretation of its significance" (Newman and others, p. 152).

Both constructivism and social constructivism are theories of learning development which focus on aspects such as students' active participation in learning activities, interaction with others, and the importance of communicating. These theories have of course influenced the pedagogies which support student centred approaches.

2.3. THE USE OF COMPUTERS IN EDUCATION

Since the early 1960s, when computers started being used in instruction, more and more elementary and secondary teachers have used computers as an educational device. In fact, the development of microcomputers, has made it possible to provide schools with equipment. "Arrived on the market in the late 1960s, the first minicomputer was developed in 1973, and the early 1980s witnessed the beginning of the incredibly rapid spread of microcomputers" (UNESCO, 1989, p. 9).

The applications of computers in education have been viewed in several ways, and we can consider that at the present time there are several approaches to the educational use of computers.

> "Attempts to develop the computer as a substitute for the teacher were replaced by extensive efforts to teach students to use a computer as a problem solving tool and by efforts to utilise the computer as a teacher aide" (Dennis and Kansky 1984, p. 3).

One of the main aspects that characterises the difference is whether: students should learn about computers or should learn with computers. This issue has curricular influence, since it determines whether there is a new discipline to be integrated in the students' curricula, or whether the computer is a pedagogical tool enabling students to learn school content and develop skills more effectively. This issue is referred to by UNESCO in the Bulletin of International Bureau of Education, (1989):

> "Hence, beginning with the 1970s, the subject of computer science in education referred to a number of activities: either the teaching of a new discipline under various forms; or the use of the computer as a tool and as educational technology. Although these various activities are not independent of one another, if only because they compete for allocation resources which are always limited, they are the object of separate sessions of symposia representing two distinct poles of attraction, two communities of protagonists, and quite often for practitioners, an alternative" (p.12 and 13).

The divergence between computer science or the computer as a teaching aid, has been an aspect debated by some authors; for example Rushby (1981) writes: "...to what extent should teaching about computers be dissociated from teaching with the aid of computers?" (p. 10).

Wilkinson and Patterson (1983), discussing potential uses of computers in schools and classrooms, mention that "different choices are undoubtedly appropriate in different settings, but there is no unifying theory that captures the important criteria for making the choices" (p. 3). The English National Curriculum describes technology as "an activity which goes across the curriculum, drawing on and linking in with a wide range of subjects" (in Design and Technology for ages 5 to 16, 1989, p. 2). The same report also states that:

> "...Technology is an area of study in its own right, with its own distinctive objectives and content. This does not necessarily mean that technology must be a separately timetabled subject" (p. 93-94).

Concerning the computer as a pedagogical tool, we can find in the literature several ways of categorising educational software which may be used for educational purposes, (e.g. Chandler, 1984, O'Shea and Self, 1987, and Taylor, 1980). Doing a very broad categorisation concerning the applications of the computer as a pedagogical resource, we can consider three situations:

(a) use of educative software as an instructional tool, as tutorial, drill and practice, and simulation programs ;

(b) use of software which was not designed specifically for educational purposes, such as word processors, spreadsheets, and data bases;

(c) the exploration of programming languages in such a way that it fosters a learning environment (for instance LOGO).

One of the computer's educational roles is to simulate traditional teaching activities , as tutorial or drill programs do.

Drill and practice is also used to consolidate knowledge; however some authors considers this kind of use a poor one. For instance, Chandler (1984), has a strong criticism related to the use of computers for programmed instruction and drill and practice, which "constitutes a hospital model of learning, with children automatically regarded as sick patients, learning as receiving treatment, and computer programs used as potent drugs" (p. 7). Others authors (e.g. Dennis and Kandsky, 1984) consider that tutorial instruction by means of computers is a function of the quality of the programs. They state that:

> "The problem for the designer of such programs is to make the computer behave as if it were a very knowledgeable and creative teacher who is engaged in a dialogue with a single student for the purpose of helping that student to develop important new thoughts" (p. 14).

The drill and practice activities are viewed by these two authors as useful for students, since they "provide a carefully monitered environment in which the student may repeatedly execute an ordered sequence of steps which makes up the procedure" (p. 15), where the computer can notify the student of any error and suggest a way of correcting it.

The simulation programs have been considered as having learning potentialities as they provide a representation of a real-world situation in which some factors can change. "Since many relationships are complicated and their outcomes often unpredicable, the simulation program creates a problem solving situation" (OCDE, 1987); thus they may help the students to understand some abstract concepts and relationships , as in Mathematics or Physics.

One of the more recent pedagogical uses of the computer concerns "content free tools" (Chandler, 1984). This software can provide a very stimulating way of learning and the development of some students skills and capacities, as is claimed by Parker (1986):

> "Computer tools, particularly word processors, data bases and spreadsheets, hold great promise for providing students with activities that develop higher level problem solving and thinking skills - skills that involve creating, analysing, synthesizing and evaluating" (p. 21).

For instance word processing is providing new ways for the student learning to read and to write, fostering new ways of communicating. Chandler mentions that "the word processor is a supportive medium for children to engage in extended writing, the only way in which they will ever become writers" (p. 39).

Databases are also a very much used form of software in schools today, as Chandler also notes:

> "Databases as methods of storing and retrieving data,....is perhaps the most obvious immediate utility to children... However children are seldom allowed to contribute to such databases,...and if we are to ensure the self-generated databases are to become serious educational aids then we must surely make them available from the earliest possible age" (p. 48).

Thomas (1988) states that when students are using databases in their social studies or science classes, "the skills associated with electronically finding, selecting, and organizing data are becomimg a part of the common curriculum" (p. 17). Spreadsheets have also been used, mainly in mathematics classroom. McDonald (1988) considers that:

> "Spreadsheets can offer students a large number of inductive experiences that allow for individualized pacing, more active student involvement, and the potential of the joy of discovering complex mathematical relationships on their own" (p. 615).

One of the potential uses of spreadsheets and of graphics packages is the possibility for students to see and represent graphics concerning relations among variables; in the study of geometry Fey (1984) considers that:

> "... first the computer provides a flexibly structured geometry laboratory, an electronic microworld between physical objects and abstract ideas. Geometry 'experiments' give immediate neutral feedback to the user. Second, the interactive mode of such investigations promises and end to the passive learning style of 'book-centred' courses " (p. 42).

Papert proposed educational microworlds, in particular the LOGO turtle microworld an environment in which students can explore by themselves a "little slice of reality, ...a safe place for exploring" (1984, p. 2). He supports the position that in doing so, they learn to transfer habits of exploration from their personal lives to the formal domain of scientific theory. Papert says that a microworld provides investigative activities so as to investigate rules and relationships. As Noss (1987) states:

> "The LOGO environment appears to offer an opportunity for children to base their mathematical activities on their existing conceptions and intuitions, and at the same time it provides a context in which formalisation appears both natural and meaningful" (p. 343).

2.3.1. Implications for education

The computer has been used to fit in with traditional methods of learning, or with those based on discovery and inquiry based learning. Using the computer as an instrument for drill and practice "appeals to teachers because it resembles traditional teaching methods" (Papert 1980, p. 36). Educational consequences of the use of computers in education are related to the learning objectives as well as to the ways in which students work with this new instrument (OECD, 1987).

The different ways that computers can be introduced and explored in educational settings "demonstrate a trend from a behaviouristic to a cognitive approach to teaching and learning in that they view computers as devices for implementing not rigid, mechanistic, statistically-based teaching systems, but ones which treat the student as a thinking, understanding and contributing individual" (O'Shea and Self, 1983, p. 120)

More than the computer programs used, it is the learning environment, the kind of activities or the projects in which students are involved, and the level of students' engagement that can determine the impact of computers in education (Beswick, 1987). For Papert (1984a), the use of computers "gives us the opportunity of making much more radical changes in the conditions of learning than other means we have had in the past" (p. 4). This author adds, that this is the way in which children "can change the way they learn everything else" (p. 8).

However there are several opinions concerning this issue, as is pointed out in the CERI document (1986), where it is stated that some IT develops abstract and theoretical thinking, creativity, communication skills and the ability to work in a group. For other people, the emphasis should be on knowledge acquisition useful for future professional life.

Fey (1984) notes that microelectronic technology raises important questions about the substance and process of education. This author goes on to write:

"Those who value student control over the learning and information technology see unprecedented opportunities for student initiative in natural learning environments- students using dynamic graphics or open-ended searches through rich data bases to discover and represent powerful ideas" (p. 2).

Also O'Shea (1983) states that computer activities enable students to explore their own intuitive knowledge and emphasises the problem-solving approach in activities with computers, which contribute to the development of general problem-solving skills. He goes on to state that:

"In simulation, the student is given the programmed model to use, not asked to write or change this program. The underlying educational philosophy of the problem-solving approach is a belief in what may be summarised as "learning by doing", as opposed to simulation's " learning by seeing" (p. 107).

The importance given to the students' role in computer activities, either more or less student centred, or more or less concerned with problem solving situations, may have different effects on students' development. Lewis (1989) refers to the need for research in this area, which should include studies on the evaluation of changes in learning by the uses of Information Technologies. Lewis goes on to state that "a few studies have undertaken pioneering work, especially in the challenging area of assessing the consequences of open learning systems" (p. 7).

Another aspect focused on in the literature is the student teacher relationship in a computer learning environment, as is mentioned by Papert (1980) who says that, students can see that the teacher is a learner too:

"A very important feature of work with computers is that the teacher and the learner can be engaged in a real intellectual collaboration; together they can try to get the computer to do this or that and understand what it actually does" (p. 115).

Educational changes can be expected from the introduction of computers in education (O'Shea and Self, 1983):

"It is usual to think of the future of computer- assisted-learning in rather concrete terms-how classrooms will be organised, how much equipment will cost, how various kinds of programs will be written, and so on. In long term, however, the main contribution of computer-assisted learning will probably prove to be its contribution to fundamental changes in educational philosophy" (p. 267).

It has been shown in this section that these changes in education caused by the use of the computer will be fundamentally a function of the learning environment and of the kind of activities to be proposed for the students.

2.4. TEACHER DEVELOPMENT AND TEACHER EDUCATION

2.4.1. Introduction

The introduction of computers in education, and curricular reforms which aim at a more student centred way of learning, are demands that teachers face in their profession, which imply new knowledge as well as different practices in their daily work in their schools. However "change is a process, not an event" (Fullan, 1982, p. 115), and teachers need support in carrying out their educational tasks and to understand as well as to be critical of innovative ideas and new resources available in their schools.

> "Innovative ideas are interpreted and reinterpreted by teachers over a period of time and translated into practice in a process that involves teachers drawing upon several different knowledge bases and interpreting and manipulating various interests" (Fullan, 1982, p. 17).

This part of the review of literature concerns teacher development, and in-service teacher education approaches which are thought to contribute to professional development of teachers. A further section examines teacher education in the context of computers in education.

2.4.2. Teacher development

A view of professional development is defined by Erault (1977) as:

"The natural process of professional growth in which a teacher gradually acquires confidence, gains new perspectives, increases in knowledge, discovers new methods and takes on new roles" (p. 10).

Some authors (e.g. Erault, 1977, Pope, 1980, and Calderhead, 1987), analysing the teacher development issue, refer to the fact that teachers possess a body of specialised knowledge and experiences which should not be separated from their professional work and improvement. According to Pope (1980), a teacher has "a pre-existing system of experience, knowledge, attitudes, conceptions of his professional role and perceptions of himself and of his world" (p. 72).

The professional development of teachers is expected to be related to factors such as their own experience within the classroom and the school context, and attendance at in-service teacher activities; they can also draw on the knowledge and experiences of other colleagues. "Teachers are persons living and working in specific settings: settings with historical, social and cultural qualities which influence teaching, learning and professional development" (Blackman, 1989, p. 3).

Teachers' development is directly related, by some authors, to teachers' practice with students, as for instance Easen (1987) who states that the way teachers prepare schemes, lessons and materials usually affects curriculum development. Also Lawn (1989) considers that to improve teaching means to improve the practice within the classroom:

> "The practice of teaching is seen, without hesitation, as being in the classroom. Practice may be improved by systematic study and reflection. In the process of studying teachers will be developing professional judgment, taking responsibility and restoring their dignity" (p. 149).

However "the classroom is a complex social organisation" (Desforges, 1985, p. 129), and teachers' activity is concerned with pupils, but it is also related to the parents, the school, inspectors, curriculum development agencies, and politicians (Calderhead, 1987 and Easen, 1985). Teachers develop professional activities beyond the classroom, for example they are assigned to a curriculum or staff development activity, assume leadership for programme or curriculum development (Blackman, p. 4), etc. Several of these aspects are taken into consideration by those authors interested in teacher development issues.

One of the aspects most focused on the literature is the importance of teachers' reflection and the difficulties they have in doing it. For instance Erault (1977), stressing the analogy between teacher development and child development notes the difficulty of teachers' exposition about their own classroom experiences. Erault states that:

> "According to Piaget the child organises this experience through "schema"; and according to Kelly people organise their experience through "personal con structs". Even though Piaget was concerned with development and Kelly with personality the comparison increases our understanding of both. It also explains why experience in the classroom is so difficult to communicate. Teacher development has to build on those constructs which already exist, and cannot easily be promoted in any other way" (p. 10).

This author also refers to "reflection upon and discussion of concrete personal experiences" as an important factor to promote teachers' professional development. He states that "the fact that teachers are at the 'formal operational' stage does not mean that they prefer to discuss at an abstract level" (p. 10). The theme of the teacher as reflective practitioner and not only as a technician has become an issue discussed by other authors:

> "Increasingly, the model of teaching as a technical process is being challenged , and a very different image of the teacher is emerging. Teachers need to be more reflective and in control of their own professional lives; they need improved working conditions that foster a professional life more conductive to collaboration and deliberation than to strict accommodation to rules and procedures" (Wildman and Niles, 1987, p. 25).

The need to reflect upon our actions is also stressed by Shon (1987), who distinguishes between "knowing-in-action" and "reflection-in-action". Knowing-in-action refers to "the sorts of know-how we reveal in our intelligent action,... by our spontaneous, skillful execution of the performance", and it is often difficult "to make it verbally explicit" (p. 25). Refection-in-action is a process through which the action is made explicit. As Shon says, "refection-in action has a critical function, questionning the assumptional structure of "knowing-in-action" (p. 28). According to Shon, practitioners become reflective through a process based on their own actions:

> "We may reflect on action, thinking back on what we have done in order to discover how our knowing-in-action has contributed to an unexpected outcome... Reflection gives rise to on-the-spot experiment. We think up and try out new actions intended to explore the newly observed phenomena, test our tentative under-

> standing of them, or affirm the moves we have invented to change things for the better" (p. 28).

Easen (1987), emphasizes that professional development is a process of "reflecting upon present practice, challenging familiar assumptions that influence what we do, exploring new ways of acting in accord with how we now see the reality of the classroom" (p. 71).

The importance of reflection on teachers development is discussed by many authors; however it is important to understand the different rationales in which these assumptions are embedded. Zeichner and Liston (1987) drawing upon the work of Van Manen (1977) clarify the issue of reflective teaching, identify three levels of reflexity:

> "At the first level of technical rationality, the dominant concern is with the efficient and effective application of educational knowledge for the purposes of attaining ends which are accepted as given. At this level, neither the ends nor the institutional contexts of classroom, school, community, and society are treated as problematic.
>
> A second level of reflectivity, according to Van Manen, is based upon a conception of practical action whereby the problem is one of explicating and clarifying the assumptions and predispositions underlying practical affairs and assessing the educational consequences toward which an action leads. At this level, every action is seen as linked to particular value commitments, and the actor considers the worth of competing educational ends.
>
> The third level, critical reflection, incorporates moral and ethical criteria into the discourse about practical action. At this level the central questions ask which educational goals, experiences, and activities lead toward forms of life which are mediated by concerns of justice, equity, and concrete fulfilment, and whether current arrangements serve important human needs and satisfy important human purposes. Here both teaching (ends and means) and the surrounding contexts

> are viewed as problematic - that is, as value-governed selections from a large universe of possibilities" (p. 24-25).

A second aspect of the process of professional teacher development is that, besides being an individual process depending on a teacher's personality, previous knowledge and past experiences, it is a social process as well (see for example Blackman, Edelfelt, and Smyth 1989, and Easen, 1987). In spite of teachers having little opportunity or incentive to develop shared knowledge (Nias 1989), teachers are living in a social context. Hargreaves (1989) notes that teachers tend to be individualistic focusing their school activity in their classroom work, and this isolation "discourages their involvement in school-wide decision-making" (p. 55). Fullan (1982) adresses this issue saying that:

> "The lack of opportunity for teachers to reflect, interact with each others, share, learn, develop on the job makes it unlikely that significant changes will occur" (p. 118).

The social interactions, through professional contacts among teachers working collaboratively, discussing and sharing experiences are seen as important factors in professional development. Smyth (1989) writes about how important is that "teachers put together coherent views of their world", which means that:

> "Rather than teachers instantly becoming critically conscious agents, they would first pass through a phase of "naming" and describing their contexts,... gradually, as they become comfortable with describing and analysing their unquestioned practices and how they come to be, teachers move towards the demystification of the wider social and cultural contexts in which their teaching is embedded. They do this through discussion, disclosure, and dialogue" (p. 228).

Another aspect referred to in the literature is the importance of the educational context in teacher development, for instance curricular reforms or innovatory projects. Curriculum development and teacher development are "closely interdependent processes" (Hargreaves, 1989, p. 165). Fullan (1982) suggests that professional development is related to learning and it involves new behaviours and practices as well as new knowledges and understandings. So it is a process of change involving two general aspects, "pertaining to what one thinks (new beliefs, philosophy, theories, knowledge, attitudes, etc.) and what one does (use of new materials, new skills, new behaviour, etc." (p. 264). This process of change is in some cases related to innovative programmes proposed by the governments or by local authorities, or may be just a social pressure in order to adapt new ways of learning and the school organisation to the new trends of the society.

> "As dissatisfaction and doubt about the success of our schools in meeting the needs of the whole range of today's youngsters continue to increase, both within and outside the teaching profession, so the question of change becomes more urgent" (Claxton 1987, p. 1).

Some authors such as Woods (1989), Kirk (1988), Dean (1991), and Claxton (1989) refer to the professional role of the teacher in contemporary society, where the rate of change has implications in the educational context. Dean, for instance, analyses the importance of the new technologies upon the actual role of the school, "which is no longer that of providing a package of knowledge and skills to serve a person for life". Dean goes on to say that students need to know how to "search and use" information, which implies an "emphasis on the skills of independent learning and on learning how to learn including the application of what is learned" (p. 1).

Microcomputers are still an innovation in society and in school (Dubuc, 1988), and their use in the educational system requires changes in schools, mainly related to the computer's potentialities in the teaching and learning processes. From the point of view of teacher development, educational innovation can be a challenge or a good opportunity to teachers, as they are the main agents of its implementation. The role of the teacher in school change depends on what they do and think (Fullan, 1982).

Issues related to the development of teachers in the contemporary educational context are also analysed by Kirk (1988) who, describing some of the social changes, considers that teacher education should provide teachers with new skills and opportunities that foster professional practice.

Teachers' implication in innovatory programmes is very important to teachers' development. Fullan argues that implementation of any educational change requires that the change has meaning for the teacher. Professional development in a context of innovation and change, is supposed to be more powerful if teachers understand the particular programme of change and are going to be involved in its implementation (Rudduck, 1991). According to this author:

"Teachers, therefore, will need opportunities for professional enrichment, for keeping abreast of developments in knowledge and pedagogy, for revitalising the practice of their craft, and for enhancing and acquiring skills that are thrown into prominence by changes in the social and educational context" (p. 16).

Teacher motivation is also an important factor that is linked to professional teacher development. Addressing teacher development from the perspective of the teacher as an adult learner, Rogers (1971) refers to the motivation issue, stating that in spite of the fact that the motives for teachers looking for new learning are mixed, "the only basic motive of every adult student is the need for achievement and reward, the need to feel 'good' at something" (p.12). Teacher's motivation to search out opportunities to improve their professional role is related to many factors in Dean's opinion (1991). They are: satisfaction of seeing that students have developed and learnt something new; teacher enthusiasm for subject matter; recognition and praise for the work they do; the chance to take responsibility and to contribute to the group in which they find themselves; the challenge to professional skills by an educational problem or a new task; the desire to be an inspiration to others within the school and outside, and the prospect of a teacher's career promotion.

About the role of the motivation Erault (1987) writes:

"The child is best motivated when following his own interests. These are often a combination of personal and peer-group interests; and pursuing them can lead to the development of a wide range of knowledge and skills. Likewise, the teacher is most motivated to study educational problems when pursuing his own problem defined in his own language" (p.10).

There are differences between children's development and teachers' development, as the cognitive level is different as well as the motivation that fosters this improvement. However the constructivist approach provides, to those involved in professional teacher development, a theoretical framework for the content and the process of teacher education (Brown 1988). Underhill (1986) analyses teachers' learning in a constructivist perspective and considers that, as with any person, their knowledge is unique to each of them, since it is "composed of personalized schemes and perceptions and the results of his or her reflective activity" (p. 3). He goes on to say that:

> "If knowing is believing, then learning is the process of developing new beliefs and of altering old beliefs. New beliefs will result from our interpretations of empirical data, our interpretations of rational argumentation, and our instinctive need to resolve the unexplainable" (p.16).

As Rudduck (1991) argues, teachers are in the position of reflecting "perhaps in a quasi auto-biographical way, on their own past experiences of schooling and higher education, and on their experiences of teaching", which enables them "to reaffirm or to restate the principles that guide their practice, and see what it is they want to change and why" (p. 91). Wood (1987) and Novoa (1988) defend the importance of conversational aspects of the life history approach in teacher development since it provides for centering on the teacher's self without putting away the social, since all personal experiences are embedded in the social with its personal and system inter-relations. According o these authors, life histories help to build up a teacher's nowledge that is meaningful for the self as it involves "constructivist modes of learning, and a conception of knowledge that embraces the affective, the artistic, the volitional and the processual, and which is grounded upon teacher experience" (Woods, p. 131).

Also Brown (1989) defends this point of view:

> "To obtain real development in teachers' classroom practices it is necessary to enable and encourage teachers to change their beliefs and attitudes...In order to accomplish such professional development there is a much greater use of the notion of teacher educators working with, or alongside teachers, providing stimulating experiences which are likely to give rise to reflection and reconstruction of beliefs" (Brown, p. 8).

According to Day (1987), professional teacher development cannot be forced, since:

> "It is the teacher who develops (active), not the teacher who is developed (passive); the need for change must be internalized if effective change is to occur; the client must have ownership of his own learning experience; and the in-service educator's role is consultative and collaborative" (p. 219).

Professional teacher development is not only related to teacher education courses, which are sometimes "associated with the transmission paradigm" (Brown, 1988). Then, as Brown states, "it is not suggested that teacher development occurs only, or even mostly, as a result of activities which form part of teacher education courses or research and development, any more than children's mathematical learning takes place only in classrooms"

(p. 6). Woods (1989) also has a constructivist conception of teacher knowledge, considering that teacher education should:

> "... promote the means by which teachers can become reflective about their own practice within their own classrooms, and through which they can 'construct' problems (as opposed to taking them for granted and knowing the means in advance) and develop responses to them" (p. 7).

Holly (1989), describes a conceptual model of Edelfelt (1983) for the personal development with four levels: the individual teacher, the staff, the school and the wider educational context. In this perspective, teacher professional development should be focused on all of them, since "all are necessary for educational development and change" (p. 175).

In summary, we can assume that personal commitment, personal experiences and reflection, and the context in which the experiences occur are elements to be considered in teacher training programmes for professional development. As Elliot (1989) says: "personal and professional developments are inseparable" (p. 206).

2.4.3. Stages of teacher development

Within the literature we can find attempts to delineate gradual stages of teacher development, from the first professional experiences with students until a phase where teachers acquire a maturity which provides concerns on more broad pedagogical issues and a lesser concern with the self (e.g. Fuller, 1969, Watts, 1981 and Pinner and Shuard, 1985).

Pinner and Shuard identify four phases of professional development: initiation. consolidation, integration, and reflection. In the first stage, teachers need to gain experience of what to teach and how to teach. Consolidation involves a growing awareness of students' needs and of organisation of teaching activities. During the third phase, the integration phase, teachers reach a greater sense of the reasons which are behind the students' curriculum, and "begin to consider the learning potential of interrelating curricular areas" (p. 157). Teachers ask questions as "why this topic is included", "why is this apparatus useful", or "why does this topic precede that one" (p. 156). Finally the reflection stage occurs when teachers have developed a personal educational philosophy. These authors note that:

> "...The few teachers who were reaching the stage of reflection whom the researcher met on and after courses, were largely found to be taking part in the challenging activities provided by real problem solving" (p. 162).

Watts (1981) and Fuller (1969) consider three stages of teacher development. Watts offers a model from the "survival" stage to the stage of "mastery", passing through the "middle" stage. In the survival stage teachers have as the main concern to cope with the "day-to-day survival" and students appear as "a threat mass" (p.36); "the middle" stage is characterised by increasing confidence and by a concentration on students' needs with the discovery of new skills in organisation of classroom activities; the stage of "mastery" is where teachers are able to relate classroom work to the rest of the school. In this phase teachers ask questions about children's thinking and "more global questions about the role of the teacher and the school in society" (p.37). Fuller suggests that experienced teachers focus their concerns on the effects of teachers' actions on pupils rather than on concerns about self and class management and discipline. In this "late state teaching phase", Fuller state the opinion that teachers are able to "mobilize resources and to make changes when failures reoccur" (p. 221).

These stages are not rigid and in spite of the hierarchy it is possible that teachers can have a regression to an earlier stage, "depending upon he degree of newness and anxiety in the situation" (Watts p. 38). The notion of regression is approached by some authors (e.g. Pinner and Shuard, Fuller), when teachers are challenged to take new practices or new roles. Nolder (1991) analyses the meaning of this term, suggesting that the regression is "partial", which means that there can be no going back to an earlier state, "since one carries the accumulated experiences and competences of later stages" (p. 276). According to Nolder, what can happen is that similiarities can be found between the feelings and concerns of experienced teachers and those of teachers who are begining their careers. She studied the introduction of curriculum innovation and its relation to teacher professional development, and conceptualized teacher development associated with radical curriculum change. Nolder developed a five stage model based on empirical data, which she called "accelerated" development. These stages identify teachers' concerns at each stage. During the first stage - Anticipation - teachers feel some anxiety from lack of practical information; they seek to get it and then they try out new ideas with one or two classes. This is followed by a teachers' commitment to new experiences with feelings of enthusiasm and willingness to compare these experiences with their colleagues (the Immersion stage). The Coping stage is characterised by a feeling of losing competence and becoming overwhelmed by demands of the new ways of working. During the next stage - Consolidation - the competence returns with feelings of self-sufficience and satisfaction from their new ways of working. Finally teachers reach the Extension stage where they integrate the new practices in a personal way and the "job of teaching becomes confortable and automatic once more" (p. 287).

Adams (1982) investigated the change in teachers' perceived problems from preservice to five years of experience, and found that at all levels teachers consider as a major problem student discipline and student motivation. A second area of concern was the impact of instruction on students. Their concern about themselves tends to decrease with increased concern related to instructional tasks "even though their classroom teaching behaviour greatly improves" (p. 43).

Rogers (1992) studying adults' learning considers that adults learn continuously throughout the whole of their lives in a personal process. He states that learning arises from one's own experiences and it could take many different forms in the way that people change their knowing, thinking, feeling and doing, according to "the personality and the prior history of the learner" (p. 16).

"At times, they will learn slowly, almost imperceptibly, at other times with greater concentration and sense of drive. The process will be uneven and will spring from many needs, some of them perceived, some of them unrecognized, so that in any group of adults there will be a range of learning responses, learning styles and learning abilities" (p. 17).

Rogers extends the notion of adults' development suggesting three characteristics about continuing learning: (a) Domains of learning (new knowledges and understandings, development of new attitudes and new interests); (b) Kinds of learning (instrumental, communicative and emancipatory learnings); and (c) Styles of learning, since people have different ways of learning. About this last characteristic, he says that:

"What does appear to be clear is that some adults learn more frequently and more effectively by thinking about things (especially their own experience) and others more by doing (for example, by trial and error); some build concepts and abstractions, others build machines and experiment" (p. 13).

To contribute to teachers development by means of teacher education, it is important to be aware of the aspects which are related to the different ways and phases in how teachers improve their professional lives. Rogers emphasises two aspects: experiential learning and a "close identity with a group which shares the new desired attitude" (p. 141). Others authors (e.g. Shon) also defend the necessity to reflect upon the practice. The next section will review the literature concerning in- service teacher education.

.4.4. In-service teacher education

Among the diversity of models for in-service teacher training we can consider those that focus on knowledge and techniques acquisition, externally provided for individual teachers, and those where the main aim is to respond to teachers' needs within the school context. In the first group, providers usually determine teachers' needs, without any negotiation with them. The second group of models for teacher training has its starting point in the problems that teachers face within the school system, providing them with the self appropriation of new knowledge, understandings and skills. To resolve the conflict between these two groups of models, here sketched in their most extreme characteristics, the "school focused" approach to teacher education includes elements of both, namely "school-based activities, course-based activities, short workshops and conferences and advanced studies for, say, an M.Ed." (Bolam, 1982 p. 217). The identification of teachers' needs, and the kind of knowledge to be addressed in teacher training programmes are two main issues referred to in the literature and these will be considered in order to clarify the different rationales in teacher education.

2.4.4.1. Identification of in-service teachers' needs

One of the main issues of in-service teacher education is "who defines the needs" (Bolam, p.218). MacLure (1989), for instance, analyses the question of needs identification from the point of view of the individual teachers observing that "these needs must somehow also mesh with the institutional, LEA and national plans for the future of the education system" (p. 76).

The problem of the methodology to use in the identification of in-service needs has been addressed by several authors (e.g. Wray, 1989, and Nixon, 1989). One method used is the determining of needs by means of a questionnaire, but this method has been considered unsatisfactory. As Wray points out "areas in which we feel ourselves in need of some help are not likely to be areas about which we know enough to analyse these areas in sufficient depth" (p. 146). Concerning the requests made by schools, Wray refers to the broad characteristic of the needs expressed, noting that "it is very much a matter of chance if the resulting in-service session happens to be precisely what is needed" (p. 145). This author considers that a process where the school staff can narrow the needs formulation defining some very precise in-service needs provides a more effective INSET provision. A perspective of school improvement by means of needs identification "involves, for example, whole school or curriculum review and teacher appraisal" (Hopkins, 1989, p. 86). According to Hopkins, this process leads to the development of a "school's problem solving capacity as well as to deal with specific problems" (p. 91).

Nixon (1989) addresses the needs issue focusing on the context in which they are expressed: "...needs are to some extent relative to the expectations fostered within particular contexts" (p. 150). Another aspect pointed out by this author is this: "To define and respond to other people's needs is relatively easy, but to focus on one's own requires a certain degree of courage"

(p. 151). However assessing our own or other professionals' needs is a hard task that requires time and reflection, as it is noted by Nixon, for instance:

> "In thinking about how to define and respond to inservice needs, then we are thinking about a deliberative process which must take account of sometimes widely differing perspectives, which must be sensitive to changing circumstances and which is inherently difficult in that it requires teachers to assess their own competence; a process, in other words, which is discursive, continous and reflective" (p. 151).

According to Hopkins, in a context of educational change, "INSET and needs identification should not be discrete activities but linked together within a whole school improvement strategy" (p. 97). Whether to define teachers' needs as just a starting point to INSET, or to include this area in the teacher training process itself, is another issue to take into consideration, in order to understand the different positions and rationales involved in teacher education. As Kirk (1988) points out, teachers' needs are identified with "a teacher's awareness of a problem in practice and the commitment to explore ways of solving that problem" (p. 48).

Day (1981), argues that teachers' awareness of their own needs is related to the teachers' commitment to the process of their learning. Researchers and providers of in-service programmes should help teachers to "define their goals and the paths to these goals, to relate these to their central needs and to develop their own realistic levels of aspiration" (p. 22).

.4.4.2. What is the most worthwhile knowledge for teachers?

To be a teacher requires "complex bodies of knowledge and kill" (Shulman, 1987, p. 4) and this knowledge is not fixed and final (p. 12).

The importance of a solid theoretical education for teachers is generally agreed, and this is not sufficient to ensure that they may be good professionals. In fact knowledge about their subject matter and about the sciences of education is important, but this is not enough, since there is not a linear relation between acquisition of theoretical knowledge and the change of teachers' practices. For example teachers should have good psychological knowledge, but this does not ensure that they better understand the pupils and their motivations, adapting strategies and methods to their cognitive level. As Smyth (1987) states, teachers as other professionals are confronted by situations that demand a performance for which they have not been prepared.

It is now commonly held that knowledge actualisation and reflection about their own activity are necessary practices for teachers in order to adequately fulfil their role.

Erault (1982) considers that the idea that knowledge acquisition precedes knowledge application is a "false assumption in the academic context" (p. 10). He goes on to say that:

> "The ability to use certain ideas about teaching in academic essays or school documents does not greatly increases the probability of being able to use those ideas in the classroom" (p. 10).

Erault discusses the teacher's learning associated with knowledge use in the academic context, the school context, and the classroom context. Concerning this last aspect this author writes:

> "A topic which may occupy one or two sessions on an INSET course may require several days of teacher effort and continued learning in order to be used in the classroom; and most of this will be in addition to the normal demands of the daily routine" (p. 11).

To develop in teachers their capacities to discuss, search, innovate and synthesise, and to discuss again, rather than providing teachers with updating information is nowadays an important objective. According to Dean (1991) it is desirable to develop teachers' learning in three main areas: 1) Appropriate background knowledge (e.g. about their profession, child development, theories of learning); 2) Classroom teaching and management skills, in order to articulate and implement school aims and policies to turn them into action with students in a coherent way; and 3) School management skills, which includes the ability to plan and to develop programmes for the staff development of their schools. Shulman (1987) organizes the desirable knowledge base for teachers into several categories: (a) content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, which represents "the blending of content and pedagogy into understanding of how particular topics, problems, or issues are organized, represented and adapted to the diverse interests and abilities of learners. and presented for instruction" (p. 8); (b) knowledge of learners and their characterisics; (c) knowledge of educational contexts; and (d) knowledge of ducational ends, purposes, and values, and their philosophical and historical grounds.

The focus just on techniques of teaching in teacher education is criticized by some authors (e.g. Beyer, 1987, Smith, 1987, and Tom, 1987), who defend the point of view of developing the understanding of educational purposes within social contexts. The fact is that "the school serves as a model for accepted practice; it is not itself an object for analysis or possible alteration" (Beyer, p.21), and this fact has the consequence that teachers usually accept the way that knowledge is communicated as natural and right. According to this author, teacher education should not be "a replication of current practices and activities", but it should provide for opportunities to "conceptualize alternative possibilities and how they may be morally and democratically accomplished" (p. 30). Tom (1987) considers that pedagogical knowledge should be replaced by pedagogical questions. Also Smith (1987) points out that questioning critically habitual pedagogical practices implies "the need for teachers to actively assume the responsibility for theory making (and theory testing)" (p. 155), which involves transformation, and that "teachers must go beyond the roles of technicians, managers or efficient clerks imposed upon them by others" (p. 162).

An issue related to this is addressed by Smith (1987) and Shon (1983) who put the question of what is the theoretical and practical knowledge in teacher education. According to Shon practice should not be a simple application of the theory but there should be a strong connection between these two aspects of knowledge. Also Smith (1987), argues that "practioner-generated knowledge that is embedded in and emerges out of action is coming to be seen increasingly as the basis for a new and emerging paradigm in the education of teachers" (p. 4).

2.4.4.3. School focused and school centred paradigms in teacher education

Both school focused and school centred models of in-service education include a variety of activities which are based on the needs of the school; this does not mean that teachers as individuals are forgotten. To integrate the needs of individual teachers with those of the whole school, is a concern of those who are working on this area, as for instance, Lockwood (1991), who says that it is important that "headteachers, and INSET coordinators try to ensure that the needs of the individual and the needs of the school are met" (p. 77).

The aim of the school focused approach in teacher training is summarised by Smith (1987) who argues that:

> "...enhanced opportunities for professional development and change can be presented through school-focused in-service work which is designed to focus on teachers' intrinsic needs to increase their professional effectiveness, to do their job to the best of their ability. In this context, where new understandings and practices do occur, they are unlikely to founder on the rocks of transference (to a different context), ownership (by a particular or group), or adoption (by unwilling parents)" (p. 219).

Hopkins (1989) discusses school focussed INSET from the perspective of school improvement:

"This approach to inservice teacher education is radically different in both form and aspiration from the traditional and ubiquitous 'one-shot' inservice workshops that have proven to be so demonstrably ineffective (Hopkins, p. 85).

"The powerful strategies for linking INSET to school improvement should fulfil two essential criteria; they need first to relate and enhance ongoing practices at the school level; and second to link with and strengthen other internal features of the school's organization" (Hopkins, p. 86).

Bell (1991), considers that the school focused approach provides for planning teacher training activities in relation to the inplementation of innovations as well as "intended developments , tasks and needs in a particular school" (p. 11).

The school-centred model has the school as the principle responsible agent for the definition of the training, closely related to teachers'needs and the problems they face inside the school. "The school-based model was based on the view of the school acting as a learning community" (Bell, 1991, p. 10). The advocates of this model consider that the process of identifying needs is easier, and the new learnings and understandings are closely related to the problems and to the process followed in solving these problems.

Easen (1981) defends the school-centred approach to teacher education, explaining that it involves both "school-based" activity, which provides the confronting of individuals and groups of teachers with real problems of the school, and also general factors. Easen argues that change is an individual process, that we "cannot really change other people", we can just provide a "structure which helps others to change" (p. 71).

o to this author co-operation among teachers within the school ontext fosters the process of problem formulation, that is "a vital, but neglected and precarious part of problem-solving" (p. 31). INSET according to Easen's ideas should be centred in teachers' work in a practical way, and should help to create the "thinking school":

> "Thinking schools' begin with 'reflecting' teachers; teachers who establish for themselves what they are, their 'limits' and how they can reach beyond them; teachers who establish an inner dialogue between the action they take and the reflections they make; teachers who establish their own 'vision' for their own practice" (p. 129).

The necessity of teacher training programmes including group work, from the perspective that the training should happen within the group by means of discussion and exchange of experience, is pointed out by other authors. For example, Romberg and Price (quoted by Campos in a conference about Sciences of Education and in-service teacher training, in Lisbon, 1986), state that teacher training is not only a problem of the persons and their skills but of the structure and organisation of the group and it is the whole school culture that is put in question.

Teacher education in the context of innovative projects to be implemented in the educational system raises the issue of teachers' implication in the implementation process. According to Campos (1986), the strategy of first elaborating a curriculum and afterwards training the teachers for its implementation, tends to be replaced by the training of teachers by their participation in the elaboration of pedagogical innovations. This uthor adds that people should not learn solutions already built or their own problems, but with support they should elaborate hem and therefore develop their skills in order that in the uture they should be able to solve the problem by themselves.

2.4.4.3.1. Action-research in teacher education

One kind of the school centred model is action- research. The action-research methodology is defended by some authors who are dealing with teacher education (e.g. Elliot and Adelman, 1975, Erault, 1982, Day, 1981, Shon, 1987). In action-research the teachers or the school define what they want to study, and apply it within a real context, elaborating some materials and evaluating its implementation. According to Elliot (1989), the focus is on "the process rather than products" (p. 205).

The improvement of the educational practice of teachers by means of school-based teacher research is also advocated by Hitchcock and Hughes (1989). These authors defend their view that through action research conducted into a particular educational issue, teachers increase their professional awareness of learning situations and classroom practices.

The necessity for teacher training to be inserted within action for pedagogical problem solving connected with reflection is also advocated by others authors (eg. Shon, 1983, Smith, 1984a, and Campos, 1988). Campos considers it to be very important that the teacher should know how to organise his intervention in each specific situation which is always changing. Teachers' changing attitudes, in particular their capacity to adapt to ew pedagogical requirements, is stressed by Smith (1984a):

> "When teachers themselves adopt a reflective attitude toward their teaching, actually questioning their own practices, then they engage in a process of rendering problematic or questionable those aspects generally taken for granted" (p. 60).

Elliot and Adelman (1975) consider that classroom based inservice teacher education is a way "to contribute to an understanding and solution of the practical problems faced by teachers in the classroom situation and to the development of a theory of teaching" (p. 106). Adopting an action research orientation, Elliot and Adelman developed a study, "The Ford Teaching Project", where one of the main objectives was "to identify and diagnose in particular situations the problems teachers face in their attempt to implement Inquiry/Discovery, and to explore the extent to which these problems can be generalized" (p. 107).

The process of inquiry in teachers' practice is present in all the models that hold that the process of teacher education occurs through focusing on the problems teachers face and critical reflexion upon them.

Tom (1985) analyses different ways in which inquiry-oriented teacher education has been conceptualized by several authors, and proposes three dimensions in order to distinguish varying approaches. They are: a) the arena of the problematic, where the central element of inquiry is the self problematization of the teachers'practice. The range of the "arena" covers, along a continuum, a set of aspects from the teaching-learning process to educational goals, including society and institutions; b) the model of inquiry by which a particular arena of the problematic is to be studied, which means the process followed by teachers in studying the problem, more or less guided by the teacher educator and more or less rigorous in terms of research. This dimension ought to unite knowledge and action; c) the ontological status of the educational phenomena dimension that influences the arena of the problematic to be addressed and the model of inquiry to be adopted. This aspect deals with the degree of reality of educational phenomena, that is the range between natural phenomena and those viewed as socially constructed. Tom's opinion concerning this last dimension of inquiry model is that teachers who have to cope every day with classroom realities "are not prone to view educational phenomena as socially constructed" (p. 43).

2.4.4.4. Teachers'evaluation of in-service education

How teachers evaluate the in-service training programmes they attend, or their participation in action research projects, are important aspects to clarify when considering the impact of teacher education on professional teacher development. According to Erault's (1982) opinion "teachers may not be able to state what they have learned or even, in some cases, whether they have learned" (p. 6). Bolam (1982) writes about the need to evaluate school focused INSET, that is usually carried out by means of questionnaires of which the "limitations have, of course to be recognized" (p. 75), since it requires knowledge about the right way of doing it. Sometimes some interviews and short statements written by participants provide additional information. Murray, MaGlashan, Hibbert, and Lenham (1982) developed a school-based anagemant course for the staff of a school. It was intended that teachers develop an understanding of the management of the school. A continuous evaluation was carried out in order to react to changes during the process and to suit client needs. The authors conclude that "participants found the course informative and stimulating" (p. 99), and two teachers produced their own ideas and materials, the whole social structure of the school being affected.

Halpin, Croll and Redman (1990) developed research in order to study the effects of in-service education as perceived by teachers. One of the results of this study show that teachers evaluate the effectiveness of their training through a connection between teacher's teaching improvement and increased level of pupils' attainment. Another result of this research is related to teachers' motivation to be involved in INSET. Most of the teachers' motives were centred on personal aspects and were not at the level of the school. These teachers cite: 1) to plan better existing curricula and schemes of work; 2) to deepen their knowledge about educational thinking; 3) to discuss and share common problems with colleagues; and 4) to develop their teaching skills. The authors discussing these results note that:

> "The individualistic way in which teachers have traditionally approached in-service provision is reflected in the way that the consequences of INSET for them tend to be less collegial, and more at the level of the individual knowledge and teaching approaches. In particular, teachers were more prone to report effects that relate to their classroom teaching than to the schools in which they work" (p. 176).

Day (1981) developed and evaluated a client-centred model in hich teachers developed strategies for classroom work and analy- ed the results, providing personal solutions for the problems hey were facing. "This model of classroom based in-service education allows assumptions held by individual teachers about teaching and learning-espoused theories to be made explicit and tested against valid information" (p. 22). All the three teachers involved, in their written evaluations, stated that:

> "Self-confrontation had enabled them to identify problems of teaching and learning. Moreover, most of their later decisions about teaching occured as a result of post-hoc reflective discusssions on their ideologies and practices and the congruities or incongruities which were revealed by the video-recordings" (p. 75).

One of the other results of this study was that all teachers had transferred what they had learnt into their work with other classes. However they commented that without the presence of the researcher, they were not able to continue with the detailed and systematic process of self-evaluation.

2.4.5. Teacher education for the use of computers in schools

2.4.5.1. Implications of computers in teaching

The introduction of the computer in schools has been a challenge for education and for teachers as well. Since they need to adapt themselves to this new medium and to significant changes in the learning environment introduced by computers, teachers are asked to solve a lot of important pedagogical issues. One of them is concerned with their own way of teaching to conduct the student learning process. As Lewis (1989) points out:

> "Teacher education lies at the heart of innovation in the classroom. Teaching styles are changing in many classrooms,.... Questions about changes arising from the introduction of IT in the classroom are only a part of a broader set of issues about the effectiveness of professional development which is offered in many forms" (p. 8).

However computers can be used to fit into a traditional way of teaching, or alternatively can be a way of teachers applying a constructivist approach to learning where students have problem solving or exploratory activities. This issue is addressed for instance by Papert (1984), who says that "traditional classroom procedures are simply transferred to new technology" (p. 8). In the document of the Commission of European Communities, "Teacher Education in LOGO-based environments" (1990), it is also stated that:

> "Certain uses of computers confirm traditional ways of teaching and learning. LOGO- in particular- gives new opportunities to the teachers and pupils.... The computer, at this moment changes the educational structure of the teaching and learning situation.... LOGO supports the specific approach to teaching and learning and this approach is called 'constructivism'" (p. 4).

From the literature it is evident that teachers are important change agents in the successful implementation of new ways of learning which are enhanced by the use of computers (e.g. Rhodes and Cox, 1989, Lewis, 1991). Then, the possibilities offered by new information technologies implies that in-service rogrammes should be generated in this innovative context (Ponte, 990). Knupfer (1989) calls attention to the fact that teachers eed to understand the change and should be helped to guide educational change. He notes that:

> "Reformers must realize that the teacher will judge the acceptability of any change by its conformity to current needs and objectives, and not according to some agenda that is foreign to the teacher's experience" (p. 20).

2.4.5.2. Inservice teacher education and computers

The OECD/CERI document (1990) about "Education and New Information Technologies: Teacher training and the role of the Universities" examines the main issues regarding teacher training in the context of the introduction of these new devices in schools and refers to previous evaluation studies undertaken, which show that in most OECD countries teacher training has been carried out as:

> "...short courses are provided outside of the schools, very often without direct connection with the subject matter to be taught and without taking into account the specific pedagogical practices of individual teachers" (p. 1).

Short courses are shown not to be effective in teacher education, especially those regarding the use of computers in classroom from a perspective of teacher development (Woodhouse and Jones, 1988, Cox and Rhodes, 1989). Teachers need support over the whole school year, although this type of teacher training is not available to a large number of teachers (see e.g. Cox nd Rhodes). An aspect focused by these two researchers was that "teachers with little or no previous experience of computer use, often do not know what they need to learn, in order to use computers effectively in the classroom" (p. 12).

Recognizing that teacher education for the use of computer in schools is a "complex and continuous effort" (p. 1), the CERI document introduces a rationale for a close relationship between universities and schools, together with the identification of significant co-operative projects between these two levels of schools. According to this document the assumptions of teacher training in this area are, in summary: 1) the training cannot be isolated from classroom reality; 2) the training should be closely linked to research and development activities in the learning process involving IT; 3) "the universities should be in a good position to help teachers (and gain knowledge from them) and, more generally, should be willing to assist schools in the introduction of new information teachnologies in order to improve the quality of education" (p. 1).

The knowledge that should be required by teachers who are, or will be using computers in the classroom is one of the main issues being addressed by those who are concerned with teacher education. The subjects cited are related to hardware, software, and pedagogical applications (e.g. CERI document, 1990, Dubuc, 1988, Woodhouse and Jones, 1988). Dubuc considers that teachers should be able to evaluate software, in order to compare and select the best, but teachers should also develop "educational skills", that is "to look at software, not as a separate entity, ut as a piece of a global educational situation" (p 69).

Woodhouse and Jones (1988) designed a teacher training programme, with different stages, that emphasised hands-on experience by teachers. taking into account the reality that teachers possess a lack of knowledge and experience in this field, the aim of this study was that teachers "know enough about computers in an educational context to make well-informed decisions on their use" (p. 315). The stages of this course for teachers cover areas such as information and practice about computer use including some software evaluation, classroom implications, course planning, and use of the planned course, where teachers must make all the necessary arrangements and decisions personally. In the two following phases teachers are encouraged to product coursework, including the integration of packages into subject areas, and finally pedagogical activities of action/reflection are approached. These phases involve alternately work in a teacher's school and work on a structured course, which "offers the opportunity for an action/reflection approach to the teacher's learning experience" (p. 320). One of the aspects focused on in this study was the reluctance that some teachers showed to admit to their ignorance, or to appear stupid about something that is related to their job. Another comment emphasized by these authors was that in spite of the fact that teachers have been introduced to these topics by appropriate methods, this does not imply that teachers use them automatically with their students, so it is necessary that teachers are given more opportunities to see how to use a piece of software in real classroom contexts.

> "What many of these teachers did not realize was that they were being taught LOGO in the way it was hoped they would teach it themselves" (Martin and Heller quoted by Woodhouse and Jones, p. 320).

Lewis (1991) defends teachers' learning through research. Lewis explains what he means by this type of research, that is "the personal research which remains the property of the individual as part of their self-development; this may be the same as what is usually called learning" (p. 3). As he writes:

> "Children gain expertise by doing research and the special value of this expertise is often stressed because children develop a sense of owning the knowledge or skill. Then if this approach works for children, why should it not be applied to adults, in particular to teachers?" (p. 2).

Hoyles, Noss and Sutherland (1989), support the idea that the way that teachers learn influences the way that teachers work within their classrooms. These authors developed a teacher training course of which the main aim was that mathematics teachers could reflect on their own learning processes in order to provide a reflection on the learning of their pupils. From the evaluation of this course it was suggested that computer based in-service programmes should include both university and school based work, with opportunities for teachers to know and distinguish among several pieces of software and their pedagogical applications and to experience their use in the mathematics classrooms. These experiences include "tried and tested computer-based materials for getting started in mathematics classroom" (p. 38, vol.II), developed by teachers themselves. They also stated that the interation of the computer into their practice needed to be sup-orted by the course pedagogy team and should be an important art of a teacher training course.

The "Project Comptown" carried out in Israel for the intro-uction of computers into education, approached a research-oriented educational intervention, and had two main objectives: 1) to create a computer culture in schools; and 2) to utilise the computer's potential for innovative teaching and learning, both in and outside the schools. The authors of this project had no direct intervention in the work developed by teachers, but they chose to observe the computer's impact and to reinforce the teachers' active involvement in the innovative processes. So, they decided to permit teachers to choose computer activities in in the classroom, not offering to the teachers a uniform working model. Teachers had several pieces of software available, from drill and practice to content-free tools. Some of the programs were being developed during the implementation of the project. Most of the computer programs were open, allowing teachers to modify them. After a year's work the researchers found that the main problem faced by teachers involved was the incorporation of computer based learning materials into the curriculum, rather than lack of technical skills. These authors stated that they "witnessed dramatic changes from traditional, routine teaching to active open learning characterised by intense, creative teacher involvement in the learning process" (p. 104). One of the signif-icant conclusions of this project was the importance of placing computers in regular classrooms in order to encourage innovative processes of teaching as well as the active involvement of the teachers. As they state:

> "The first essential condition for any innovation in education is the active involvement of the teachers, who should consider themselves partners, not merely instruments carrying out a program imposed on them" (p. 104).

2.5. SOME IMPLICATIONS FOR IN-SERVICE TEACHER TRAINING PROGRAMMES

The issue of incorporating the use of the computer into teachers' practices, with the aim of promoting a student centred approach in the learning process, influenced the designing of the teacher training programme of this study. More than providing teachers with technical skills, it was intended to contribute to the development of inquiry, reflective and collaborative skills.

The identification of teacher' needs in the context of the use of the computer in education was a crucial aspect in the conception of this programme. Day (1981), Kirk (1989), and Bell (1991) defend the premise that teachers' awareness of their needs is fostered by their involvement in the learning, and in their commitment to exploring ways of solving meaningful problems raised by practice. In this perspective this teacher training programme intended to include the process of identifying teachers' needs in the programme itself, and not just as a starting point. These issues were related to the content approached during the course, which should be closely related to teachers' needs concerning their future work with students using computers.

Teachers' involvement in innovative programmes is addressed, for instance by Fullan (1982), Dubuc (1988), Kirk (1988), and udduck (1991)) who claim that it constitutes a good opportunity for professional development. Hence this principle was built into the programme; teachers' involvement in developing innovative programmes both draws on existing expertise and forces teachers to consider new ideas. The teacher as a learner, as well as the teacher as a professional (Brown, 1988), were two main roles for teachers who were attending this programme; these two aspects influenced the options which were being taken for the design and implementation of the in-service teacher training programme.

It is usual to see teachers behaving towards their students using the same techniques and methods with which they are taught (Hoyles, Noss and Sutherland, 1988). So, there was the concern of training teachers according to the methods which it is expected they will use later on with their students. Project work (Dewey, 1938, and Kilpatrick, 1951) can offer the teacher a method to make learning meaningful, as it can link knowledge acquisition to the learners' experiences and former knowledge. The purpose of a project chosen to be developed, and the phases they have to come through in order to have a final outcome, create a rich educational context (e.g. Bothmer, 1980). It is important for teachers to experience a new method for themselves so that they can better evaluate it by reflecting on their own learning.

The OECD/CERI document (1990) emphasised the importance of a direct connection between computer knowledge acquisition and the pedagogical practices of individual teachers. In technology education teachers are learning a new subject and it is expected that they will integrate it in their teaching practice. Knowledge cquisition is a dynamic process in which both students and eacher should be approached as having common features in terms of learning by discovering. These ideas imply that participants would reflect on their own learning (Underhill, 1986, Day, 1987, Wood, 1987, Brown, 1988, Novoa, 1988, Hoyles, 1989, Rudduck 1991), as well as on their practices (e.g. Shon, 1987, Easen, 1987, and Zeichner and Liston, 1987). Since the teaching/learning process requires an inquiring and experiential attitude of teachers, teachers should acquire habits of reflection and critical thinking about their own practice in order to improve and innovate in the teaching/learning process.

It was expected that some teachers would be insecure in using computers as a pedagogical tool within their schools; working in a group they probably would feel more confident, as they would work with their colleagues, sharing responsibilities, exchanging experiences and elaborating educational materials. Discussing concrete experiences with their peers, working collaboratively is seen as important in the process of teacher development (Fullan, 1982, Smyth, 1989, Hargreaves, 1989).

2.6. CONCLUSION

I have classified this literature into three main parts: active learning; use of computers in education; and teacher development which includes a review of teacher education paradigms. This last section also sets out aspects related to teacher education for the pedagogical use of computers. Since this thesis is concerned with the conception, implementation, and evaluation of a inservice teacher training programme for teachers who were nvolved with computers in schools, all these aspects were impor- ant to this study. Some implications of the literature in the design of the programme were above referred.

The active learning section was studied as one of the objectives of the teacher training programme was to influence teachers to have a more student centred approach.

The introduction of computers in Portuguese schools was very recent, when this study began. So I felt the need to review this theme and to deepen may knowledge concerning this issue.

Throughout my research all these aspects were also reviewed and studied during the development of the programme, fieldwork and data analysis. Even the teacher education paradigms were mostly studied when the programme was going on, and after, because this interaction between literature, practice and evaluation enabled me to understand better this issue in the perspective of teacher development.

The following chapter describes the teacher training, its fundamental characteristics, the objectives, the phases and the activities in which twenty nine teachers were involved during the school year of 1987/88.

CHAPTER 3

THE IN-SERVICE TEACHER TRAINING PROGRAMME

3.1. INTRODUCTION

A pilot study was undertaken during the year before this programme, which is briefly described in this chapter, as well as its influence on the design of the programme of this study. Details are given in annex PS. This chapter also describes the in-service teacher training programme, its development through the school year 1987/88, and includes a brief characterisation of the teachers involved in this study, as well as the schools where they worked.

3.2. THE PILOT STUDY

A pilot study (see annex PS) was implemented in 1986/87 and the results were taken into account in the designing of the main structure of this teacher training programme. The pilot study consisted of the development of an in-service teachers course for twenty two teachers, all participants in the MINERVA project. This programme was developed in two phases as follows:

First phase: Four days workshop approaching the Work Project methodology.

Second phase: 1) Technical training about spreadsheets, data bases, word processing, drawing applications, and an initiation into the LOGO language.

2) Monthly seminars for discussing pedagogical themes related to the use of computers and for exchange of experiences and reflection on the ongoing activities in the schools.

3) Implementation and evaluation of teachers' project activities in their schools.

3.2.1. Influence of the pilot study on the design of the programme of this study

The main difference between the two programmes lay in the training approaching the work project. The four days of workshop during 1986/87 was too short and teachers claimed that there was lack of time. Teachers did not have time to experiment with the whole process; more time was needed to reflect in groups and to develop field work that could be useful to the final product.

Technical training was approached in the same way for all the teachers, and it was not mainly concerned with the projects which teachers were developing in schools.

These two aspects, the work project and the technical training were the main aspects which were reformulated in the programme for this study. However other components such as direct support, visits to teachers' schools and the formal presentations of teachers' work were introduced in order to adjust the training to the teachers' needs.

3.3. DESIGN OF THE PROGRAMME

The programme was designed for teachers who were beginning to work with computers in educational environments within their schools, in the context of the MINERVA project.

The programme was designed for one school year, beginning in the middle of September of 1987 and finishing in the end of June 1988, with an initial workshop in July 1987 just before the school holidays. My intention was to provide a continuous link, during a whole school year, between teachers involved in the programme and the Node of Minerva at my School of Education in Lisbon, in order to support teachers in the development of their projects using computers with students. The idea was not that teachers should complete the training programme to learn new subjects, and afterwards start working with computers in their schools, but that the training and the work with students came together. However it was expected that the programme could help the teachers to become more and more autonomous in their process of knowledge acquisition, creating habits of working in a group. New software was constantly appearing and when the MINERVA project was over it was hoped that they could work with their colleagues in the school without support.

It was intended with this programme:

a) To provide technical knowledge integrating the computer into educational activities.

c) To promote an approach to the teaching/learning process in an active and participative way for school students, motivating them to adopt an attitude of investigation and inquiry.

These two mains goals were pursued through a methodology of active participation by teachers where they could reflect on their own learning, and on their educational practices, attaining the following specific objectives:

1. To encourage the capacity of teachers to explain their interests and needs as a main feature for their training.

2. To provide a participative intervention of teachers in their own learning process, promoting the development of capacities for planning, implementing and evaluating pedagogical activities.

3. To develop a scientific attitude through investigation activities, integrating theoretical knowledge with their professional practice.

4. To develop the capacity of team work through sharing knowledge and experience, and designing educational materials.

5. To stimulate the self confidence and initiative of teachers.

6. To promote the awareness of the importance of intrinsic motivation in knowledge acquisition.

7. To provide a view of knowledge in a interdisciplinary perspective.

8. To promote the awareness of social aspects in the learning process.

3.3.1. Main characteristics of the programme

The programme was in three main phases, the first one (during the 1st school term), being the development of a work project in the context of the introduction of computers in educational environments. Two introductory phases (in July and September, one week each) introduced some initial knowledge about computer technology, and experience of some software, as well as some opportunity for discussion about the educational possibilities of the computer. Table P summarises the phases of the programme.

This programme was intended to be a flexible one. During the introductory phases as well as in the first phase the training was conceived as the same for all the teachers involved. The programming and planning of the second and third phases were to take into consideration teachers opinions and needs concerning the development of school activities, with the training diversified from the time that teachers began to work with their students.

Table P: Phases of the programme

Phases	Dates	Objectives
Introductory	July (one week)	Provide an initial knowledge in computer technology
	September (one week)	Provide some discussion about educational potentialit s of computers
1st Phase	October 7th - - December 10th	Experiment and evaluate the work project methodology
		Begin the organisation of computer club in schools
		Provide technical knowledge
2nd Phase	January 7th - - March 24th	Support teachers in the implementation and evaluation of students activities
		Create habits of exchange of experiences
		Provide a wider technical training
		Discuss pedagogical aspects of computers in education
3rd Phase	April 14th - - July 14th	Increase technical knowledge according to teachers' needs
		Promote visits to teachers' schools and the exchange of experiences
		Provide discussion and reflection of pedagogical issues
		Provide the definition of new projects for the following year

3.3.2. Initial plans for the different phases of the teacher training programme

The early phases were intended to provide the teachers with an elementary technical knowledge and a general view about the educational possibilities of computers, in order to enable teachers to begin working with students as well as to start on the project work. During the three main phases a more developed technical training, seminars providing discussions and sharing of experiences, as well as pedagogical reflections concerning the use of computers in student activities were expected to be developed throughout the school year. However the programme would be specified according to teachers' reactions as well as teachers' interests and needs arising from the projects which they would like to develop in their schools.

3.3.2.1. First phase: October 7th to December 10th:

During this phase teachers would be involved in a project work course developing a project chosen by them related to the use of computers in primary and preparatory schools. Interposed-with the development of the work project, workshops approaching some software would be provided in order to provide the knowledge of programs which could be used with students in school activities. Also during this period teachers would be asked to organise the computer clubs, and to begin to think about the choice of students, as well as the first activities to be developed with them.

3.3.2.2. Second phase: January 7th to March 24th

During this phase it was supposed that teachers would work with their students in curricular and extra-curricular activities involving them in project works or other activities with computers. The activities that teachers developed with students would be chosen by them and would not be suggested by teacher educators. During this phase it would be expected that the teachers would be going through with their students the same phases which they had experimented with themselves, as well as reflecting and evaluating of this pedagogical approach.

Teacher educators would be available to provide some support in the developing of teachers' work in their schools. Teachers' exchange of experiences was also planned to happen in this phase. Also technological training would be offered to teachers according to the projects which they would be developing with their students.

3.3.2.3. Third Phase: April 14th to July 14th

The emphasis would be given to theoretical discussions related to the pedagogical issues emerging in the former phases. However more technology training would be offered according to the teachers' needs; for instance, teachers who needed to know something more about LOGO would have another seminar, teachers who needed databases would have a databases seminar. An increase of exchange of experiences and materials among teachers was expected to be one of the characteristics of this part of the training.

3.4. TEACHERS INVOLVED IN THE PROGRAMME

Twenty nine teachers were involved, six of them being Primary school teachers (for ages 6 to 9/10), from three Primary schools, and twenty three being "Preparatory" school teachers (middle school), from five Preparatory schools (for ages 10 to 11/12). One of the Primary schools (school H in the following table S) was actually a special school for boys with social problems aged from 13 to 18 years old. The set of the Preparatory school teachers consisted of nine Mathematics teachers, four Social Studies and History teachers, four Craft and Design teachers, three Visual Education teachers, two English Language teachers, and one Natural Science teacher. The average of years of experience as teachers was twelve years, but twenty three teachers had twelve or more years of experience (12 to 28), there being just six teachers with 3 to 8 years of teaching experience.

These teachers were involved in the implementation of computers as an educational resource in the MINERVA project for the first time. Only two teachers of students at the preparatory level already had some knowledge about computers, as they belonged to the population of the pilot study, developed during the previous year, (see annex PS). All these teachers used computers on an voluntary basis. As the MINERVA project was in an experimental phase, only the teachers who showed the desire to work with computers with their students were proposed by their school board to take part in the project. So each of the teachers in the preparatory level had four or five hours free of classroom work in order to attend training courses and to develop computer activities with students. All the 23 teachers at preparatory level had the Thursdays free of classroom work in order to attend the course at the Higher School of Education. Once every fortnight teacher educators went to the schools to give them direct support. The primary school teachers needed to ask permission from the principal of their schools to miss classroom work. However they did not attend some sessions, as they just worked with LOGO, the Drawing program and word processing. For these teachers there was direct support every week by teacher educators in charge of the primary level.

It was also expected that teachers involved were going to introduce the ideas and knowledge to their colleagues in their schools when they felt confident to do this task.

3.5. CHARACTERISATION OF THE TEACHERS' SCHOOLS

Teachers involved in this study belonged to eight schools of which the characteristics are described, in summary in the following table. These schools were not specially chosen for this study, they were the schools that applied to be integrated in the Node of the MINERVA project of the Higher School of Education of Lisbon in 1986/87 and 1987/88.

Table S: Characterisation of the schools

School	Level	Nº of teachers in school	Nº of teachers involved	Year of beginning Minerva P.	Nº of other clubs
A	Middle	116	5	86/87	2
B	Middle	62	3	86/87	1
C	Middle	36	4	87/88	1
D	Middle	90	5	87/88	2
E	Middle	110	6	87/88	12
F	Prim.	23	1	87/88	__
G	Prim.	9	1	87/88	__
H (special education)	Prim.	4	4	87/88	*

* This school has compulsory craft workshops where the students spend an half of the school schedule working, mainly with wood'.

3.5.1 Other school characteristics:

The schools were located in Lisbon or in the surroundings. Seven of these schools were for both boys and girls as are almost all of the Portuguese schools. Only School H was single-sex, for boys who had family and social problems with a personal history of persistent school failure and study rejection. This school was integrated in the Court of The Ministry of Justice, for under aged boys, and the students belonged to lower status families in social areas with problems in Lisbon. The other schools had mixed students belonging to lower and middle status families.

Preparatory schools are directed by an elected committee of three teachers who are in charge of administering and managing the school. Primary schools have a principal also elected with the same functions. In both cases there is a pedagogical council which discusses, analyses and decides some of the school activities. In Preparatory schools this council consists of teachers who coordinate the various curricular areas and in Primary schools all teachers attend the meetings. To be integrated in the Minerva Project, schools needed to apply to a University or to a Higher School of Education where a node of the MINERVA project existed.

Teachers worked in the Minerva Project on a voluntary basis, being in some cases asked to participate by the school administration (schools E, G and H). However in most cases, teachers took the initiative and proposed the integration of the school in the Project to the school administration (schools A, B, C, D, and F). The pedagogical council was informed about this integration and about computer activities, but in all the cases it did not intervene in the choice and development of these activities. Teachers working in the Minerva Project in each school had a great deal of freedom in choosing computer activities. The initiative genuinely came from the teachers and related to their various interests and school contexts.

Teachers linked to the project were expected to provide some computer workshops for their colleagues in their own schools in order to begin to inform them about this new subject.

For each school there was a coordinator of these teachers, except in two primary schools where just one teacher was involved in the project. This teacher's role was to coordinate activities, and to be the administrative link between their school and the Higher School of Education. The coordinating teachers attended the meetings with their colleagues in order to coordinate the work that was being developed in each school. She also was the link between the node and the school concerning administrative aspects. This teacher did not receive special training and attended all the same training activities as the other teachers. At the beginning of the school year the coordinating teacher was chosen by their colleagues, and the node was informed about the choice.

3.6.THE TEACHER TRAINING TEAM

During the school year 1987/88, the year of the implementation of the programme, the teacher training team was composed of five teachers, including me, the author of this study, who was the coordinator, and who was the responsible for this Node of the MINERVA project. One of these educators also taught Mathematics at the Higher School of Education of Lisbon, in pre-service education. The other teacher taught Natural Science and Mathematics in a preparatory school and she was completely free of classroom work having been placed in 1987/88 in the Higher School of Education to collaborate in the teacher training of the MINERVA project. This teacher was chosen by me as she had attended the training courses of the previous year and was linked to the project through her school (school A). These two teachers had no experience as teachers educators in in-service education, but they were involved in the whole planning and implementation of this programme.

The other two teachers were linked to pre-service education in an Institution training primary school teachers, and worked on a part-time basis in the MINERVA project. They collaborated in the training courses mainly for primary school teachers, in direct support in schools, and in the plenary sessions when teachers did a presentation of their work.

All these teachers possessed little knowledge about computers and about computers in education, as this was a new subject in the Portuguese educational system (the Minerva project began in 1985). So both they and I had to work hard to increase our knowledge in particular about the use of software in an autonomous way, with some support from the Faculty of Sciences in Lisbon.

Regular sessions had been held previously in order to prepare and discuss the strategies, calendar of activities, evaluation, and reflection on the teachers training programme.

3.7. SOFTWARE USED

All the software used was for MSDOS machines, with the GEM environment integrated. The packages were:

1) LOGO WRITER: LOGO with four turtles, and word processing integrated.

2) First Word Plus: Word processing for GEM.

3) GEMPAINT: Drawing program for GEM.

4) PC QUEST: Data base

5) SUPERCAL3 (SC3): Spreadsheet

6) "Trinca espinhas" and "Limonada": two Portuguese educational programs; the first is a game approaching prime numbers, and the second a problem solving situation fostering mental computation.

3.8. DEVELOPMENT OF THE PROGRAMME

3.8.1. First introductory phase: July 1987

Teachers attended two workshops concerning word processing (1st Word Plus) and a drawing program (GEM paint), in July just before the school holidays, (one week), in order to understand the main commands and potentialities of these two programs.

During this week teachers worked on some activities suggested by the teacher educators and on the last day they were asked to develop a free project which involved integrating word processing and the drawing program.

3.8.2. Second introductory phase: 14 to 18 of September 1987:

A week's workshop was implemented with the following subjects:

- Operating systems (a brief introduction to MSDOS and GEM)
- Educational software (some educational games and mathematics programs).
- LOGO WRITER (just an introduction - teachers were asked to draw using some elementary procedures, and then introduced to the

idea of a variable)

- PC QUEST (just an introduction)
- SUPERCALC 3 (no "hands on" but just a presentation with display writer, in order to let teachers see what a spreadsheet was and to see some examples)

With the exception of the spreadsheet, during this phase, teachers developed practical activities working two at each computer.

3.8.3. The first phase: October 7th to December 10th

This phase lasted two months and an half, all the first school term. The agenda and the schedule of this phase was the following:

Agenda and schedule: The first school term, from October to December

October

7th Brief presentation of the project work methodology
Choice of the problem to be studied by each group
Beginning of the planning of the field work

8th LOGO WRITER (development of the initial training and pedagogical discussion)

15th Free activities *

22th Work project interviews with teacher educators

29th PC QUEST (database)

November

1st Free activities *

12th Work project interviews with teacher educators

19th Teachers prepared the final presentation of the projects

26th Free activities *

December

3rd Presentation and discussion of the projects by the whole set of teachers involved

10th Discussion of the process experimented during the development of the projects

* During these days teachers were doing field work, or they were practising work with computers in their schools. Also they had the opportunity to work together on the project that they were developing.

In the first session, teachers were asked to write a sentence about their expectations about the use of computers as an educational tool. The analysis of this sentences as well as a detailed description and analysis of this phase are in chapter five.

After a brief introduction about the work project methodology, teachers had the possibility of choosing a problem in a small group discussion, related to the introduction of computers in school. These groups were formed according to schools. Each group defined strategies to investigate, the planning and organisation of the field work, the data collection, data analysis and selected forms of presentation of the results to their colleagues and to the training team. Some interviews were done during the process by me in order to orientate the work, to provide reflection on the process that each group was experimenting with, and to gather data which is presented in the fifth chapter.

The themes chosen by teachers were:

LOGO in Primary schools;

The computer club within the school: interactions between computer club and the school;

How to involve the school in the use of computers as an educational resource;

How to organise and to make a computer club in school work;

Independent work in the Mathematics classroom including preparing the environment and class management for the introduction of computers.

The final presentations took place on 3rd of December; each group having delivered to their colleagues a short written report which synthesised their work. During these presentations teachers also discussed their difficulties and the processes they had gone through.

Following each presentation, teachers asked their colleagues for explanations concerning points that were not clear as well as about some issues emerging in the presentation.

In the following week, also in a plenary session, there was an evaluation of all the work carried out in the first phase. The written statements of the first phase (for which anonymity had been asked) were exposed on a placard and teachers were invited to identify their own sentence and to think about any change of opinion after this first phase. Also a questionnaire was distributed to complete individually. The session ended with a discussion in a plenary session; it focused on the progress teachers had made during this two and a half month training course, and teachers had the opportunity to give their opinions concerning the training received as well as suggestions for the next phases of training.

It was intended with this phase that teachers involved in work with computers should experience a methodology which they could work with later on with their pupils, and which could promote children's learning experiences where they could develop their abilities to understand and analyse information, or investigate and solve problems. Also during this phase the teachers had some seminars about computer education: LOGO and database.

The specific objectives of the first phase were:

1. For the tecthers to experience the project work methodology, thus beginning the study of some issues relating to the introduction of computers in schools.
2. For the teachers to begin the organisation within their own schools which would enable future work with computers.
3. To provide for some acquisition of technical knowledge by teachers.

3.8.4. The second phase: January 7th to March 24th

After the observation and analysis of the work developed with teachers in the first phase, as well as the analysis of results of the teachers' answers to the first questionnaire, the programme was orientated to support the teachers in the development of activities with their students and included the following aspects:

- more detailed technical training

- pedagogical reflection on the programs used
- exchange of experiences among teachers, including visits to each others' schools.

The agenda and the schedule was as following:

Agenda and schedule: the second school term, from January to March

January

7th Designing the activities to be developed with students during the second and third school terms.

14th Morning: Gem Paint

Afternoon: Technical and pedagogical seminar (LOGO and SC3, two groups)

21th Morning: Presentation of "Social Studies project" an experience developed by a group of teachers from the Faculty of Sciences, integrating word processing, Gem paint and Data base in the Social Studies curriculum

Afternoon: PC QUEST

28 Morning: Technical and pedagogical seminar (LOGO)

Afternoon:Technical and pedagogical seminar (SC3)

February

4th Visit to a school

11th First Word Plus (in greater depth, with integration of drawings in texts

18th Technical and pedagogical seminar (SC3)

25th Morning: Technical and pedagogical seminar (word processing)

Afternoon: Exchange of experiences and discussion about the work developed so far

arch	
rd	Visit to a school
0th	Educational exploration of LOGO
17th	Educational exploration of SC3
24th	Evaluation of the work developed during the 2nd term

According to this agenda, teachers were involved in a programme concerning more detailed technical training, a pedagogical approach to software, exchange of experiences and visits to one another's schools. During this second phase, teachers who had not previously done so began computer activities with students. To carry out this work sometimes teachers asked for some extra technical support and felt the need to speak either with me or my colleagues in order to discuss some pedagogical issues of their work.

Direct support in teachers' schools began during this phase. Teacher educators went to teachers' schools and were available to clarify technical aspects or help the teachers, discussing with them any problems they had with the development of the projects.

Also two schools were visited in this second part: a Primary School with special students who were internees in an institution of the court for under aged boys, and another Primary School.

During the last session (24th of March), teachers presented the work developed in their schools, and talked about the experiences they had been through. They were asked to focus on the process experienced. The reactions and social aspects of student/student and teacher/student interactions, were the aspects most referred to.

The objectives of this training phase were:

- To provide the development of activities with students where the work developed in the first phase could be applied;

- To support teachers in the implementation and evaluation of that work with students;

- To create habits of exchange of experiences and knowledge among teachers with constructive criticism and evaluation; and

- To provide a wider technical training and pedagogical approach to the use of computers in education.

3.8.4.1. Characterisation of the different training activities of the second phase

The activities of the second term were grouped into 3 categories: the exchange of experiences/visit to schools, the technical-pedagogical seminars and the pedagogical explorations of certain programs.

3.8.4.1.1. Exchange of experiences/visit to schools

During the days reserved for the exchange of experiences, teachers looked into the work accomplished by their colleagues and other colleagues who had experience in work developed with the computer. Teachers talked over and shared their experiences and their difficulties in implementing student activities, as well as activities concerning the training of other teachers in schools.

During these sessions teachers also explained what they were doing in their schools and then a discussion concerning pedagogical, organisational and technical aspects took place.

During this phase there were two visits to schools. The organisation and reception of the invited teachers was the responsibility of those who belonged to the Computer Centre of each school.

3.8.4.1.2. Technical Pedagogical Seminars

These seminars consisted of technical training in the different programs used. The activities for the teachers to become well acquainted with the most important technical aspects for future development were carefully prepared by the training team. The strategy of the activities was organised thoroughly in pedagogical terms giving the teachers examples of experiences they would be most likely to go through with students. For instance, with LOGO, we provided activities which were supposed to give suggestions for further work with students, and also giving the teachers time for them to create their own projects.

3.8.4.1.3. Educational exploration of the Programs

In these seminars the subject discussed was the pedagogical potentialities of certain programs and suggested activities to be developed with students in computer clubs and curricular activities. One of the programs discussed in one of these seminars was the spreadsheet SC3. The seminar started with the presentation of an invited teacher's work who was doing her masters degree in mathematics education using spreadsheets to approach proportionality and problem solving for second grade students of preparatory level. After this presentation questions were asked by the teachers attending and then a discussion on the educational advantages and disadvantages of this program took place. A similar seminar was also held about LOGO, another about to use of a Data Base in Social Studies, and another related to word processing.

Attendance at these seminars was not obligatory; teachers attended these seminars according to their interests, experience, and future projects.

3.8.5. The third phase: April 14th to July 14th

In the end of the second phase, teachers completed a questionnaire to evaluate the training developed so far, and also to gather information concerning teachers' opinions about the theoretical aspects to be focused on during this last phase.

Technical training continued to be provided according to teachers'needs in order to support the development of the school projects. The technical pedagogical seminars were not attended by all teachers, but only by those who were interested. This fact was already happening during the last period, but was being more defined in this final school period inasmuch as the work with students was more advanced. Three main groups were formed around several programs: the spreadsheet, the word processing and the drawing program, and LOGO.

Some direct support was asked for during this phase. However this was not a very frequent occurrence.

Teachers showed they appreciated the visits to each others' schools, having visited three schools during this period. During these visits teachers of these schools showed their colleagues the students working with computers, as well the work which they were developing. One of the preparatory schools visited invited a colleague from the Node of MINERVA project of Faculty of Science to present the work that she was carrying out in her school with LOGO. This work was very much appreciated as it was done with "shapes" and with movement, and it had engaged teachers of several disciplines and several students. This session provide a great and enthusiastic discussion concerning this version of LOGO (LOGOWRITER).

Pedagogical reflection and discussion concerning issues which emerged from the work with computers developed in schools, during the first and second school periods was the main characteristic of the third phase of the teacher training programme.

Agenda and schedule : The third school term: form April to July

April

14th \ Designing of the work to be developed during the third school term

21th Morning: Operating systems MSDOS and GEM

Afternoon: Technical pedagogical seminar on spreadsheet

28th Morning: Visit to a school

Afternoon: Discussion/reflection seminar "The use of computers within the classroom"

May

5th Morning: Exchange and discussion of experiences

Afternoon: Technical pedagogical seminar (GEM PAINT)

12th Morning: Visit to a school

Afternoon: Discussion/reflection seminar
"LOGO in elementary schools"

19th Morning: Educational exploration of word processing

Afternoon: Discussion/reflection seminar
"the role of the computer club in the school"

26th Morning: Exchange and discussion of experiences about the spreadsheet

June

9th Morning: Discussion/reflection seminar
"the role of teachers in charge of dynamizing activities with computers"

16th Visit to a school

23th Morning: Teachers presented the projects developed by their students with computers

Afternoon: Evaluation of the work

July

14th Designing activities with computers for the following year

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The final presentation constited of a full day exhibition open to any teacher who wanted to visit it. This meeting took place at the Higher School of Education. Some of the work was displayed on the walls and on the tables, and some computers also showed some students' projects. Also teachers had the opportunity to explain their work, the way they developed it, their students' attitudes towards computers, the reactions of their colleagues in their schools, and their own process of change during all this year. Each school made their own presentation lasting about twenty minutes.

Later on, an evaluation session took pace, but now only with the training team and the teachers involved in the teacher training programme.

The organisation of the work for the following school year took place one week after this final presentation.

During these two and an half months teachers were expected to develop activities in their own schools, involving students and in some cases also other teachers.

The objectives for this last phase were the following:

1. To increase technical and pedagogical support as requested by teachers for the accomplishment of projects taking place in schools.
2. To provide discussion and reflection of pedagogical issues related to the work developed so far.
3. To promote the exchange of experiences.
4. To evaluate the whole course experienced during the year, in order once again for the final time to encourage teachers to undertake reflection.
5. To provide outlines of new projects to take place the following year.

3.8.5.1. The discussion / reflection seminars of the third phase

There were several themes which were discussed in these seminars. These themes were suggested by teachers in the answers to the second questionnaire and through informal conversation. The following aspects were discussed: "The computer within the classroom", "the role of the computer in the school computer club", "the role of teachers in charge of stimulating computer activities in schools", and "LOGO in elementary schools".

The seminar "The computer within the classroom" is described in this chapter; for the others a detailed description is given in annex TT.

3.8.5.1.1. The computer within the classroom

The objective of this seminar was to provide discussion about some different ways of using computers within the classroom and their influence on students. After a brief introduction about the evolution of the use of computers in schools, mainly in Portugal, teachers were provided with three written descriptions of classes where the computer was used in different ways as an instruction and learning device. Teachers were asked to analyse these three kinds of classroom activities and to relate them to their likely influence on students' characteristics, after a long period of work. A discussion among teachers, first within a group, and afterwards in a plenary situation, took place after the individual analysis of the text. Another activity in this seminar was discussion of the role of the computer in different teachers' pedagogical approaches: The "authoritarian teacher", "the behaviourist teacher", the "interactionist teacher", and the "non directive teacher". A theoretical text was distributed and read in order to distinguish these designations, in fact stereotyped ones, but providing some references for teachers' discussion. The discussion was coordinated by one of the teachers of the training group, who was concerned not to express her opinion of the best way to use computers in a classrrom setting. At the end of the seminar, some conclusions were summarized, and other short texts were distributed for later reading.

CHAPTER 4

RESEARCH METHODOLOGY

4.1. INTRODUCTION

As stated in the first chapter, this study aims to gain understanding of the influence of an in-service teacher training programme for teachers involved with computers in education. The impact of the programme on teachers was studied in relation to three main themes:

1) Teachers' attitudes relating to the use of computers in schools, both in curricular and extracurricular activities;

2) Teachers' attitudes concerning both the teaching and the student learning process;

3) Teachers' views about their own professional development.

It was also intended to elicit teacher's views concerning the different components of the programme in order to introduce further improvements.

The main research study was conducted in two major stages. The first, lasting one year included the development of the teacher training programme, with twenty nine teachers of Primary and Preparatory schools. The second, lasting another year, only concerned the eight mathematics teachers, who were studied in depth.

The in-service teacher training programme, which a description and development is g in the previous chapter, took place between September 1987 and July 1988. Its evaluation lasted two school years: 1987/88 and 1988/89. However the last interview was carried out in October 89 for reasons to be explained.

The following table shows a summary of the main types of data used in this research. The data collected and the analysis process followed in this study will be described in some detail later in this chapter.

Table R: Phases of the Research

First stage: 1987/88

Phases of the programme	Type of data	Date
First phase: 1st school term of 87/88	Field notes	Oct/Dec. 87
	Work project interviews 1, 2	Oct/Nov. 87
	Work project presentations	Dec. 87
	Questionnaire 1	Dec. 87
Second phase: 2nd school term of 87/88	Field notes	Jan/March 88
	Questionnaire 2	March 88
Third phase: 3rd school term of 87/88	Field notes	April/July 88
	Presentations of teachers works	July 88
	Questionnaire 3	July 88
	Interview 3	July/Sept. 88

Table R: Phases of the Research (cont.)

Second stage: 1988/89	Type of data	Date
	Field notes	Throughout the year
	Interview 4	Feb/March 89
	Interview 5	Oct. 89
	Materials developed by teachers	Throughout the year
	Classroom and computer club observations	Feb/Mar 89 May/June

4.2. SELECTING THE METHODOLOGY

As was described in chapter three, the teacher training programme of this study was not completely defined at the beginning, but was adjusted according to the teachers' needs. The content also evolved in accordance with the development of the teachers' projects in their schools. So some of the data gathered during the first year, mainly teachers' opinions, was meant to contribute to defining some of the teacher training activities during the course.

A case study paradigm was selected. This allowed the possibility of studying the programme by following the teachers during its development and implementation, studying how they reacted towards the computer, how they integrated the computer into their educational practice, and any changes concerning their teaching style.

This study used a qualitative approach in the gathering, analysis and interpretation of data. The process of analysis was fundamental in this work and it was also done during the development of the programme.

> "Innovative programs are often changed as practitioners learn what works and what does not,...Such conditions call for a dynamic evaluation approach that is process-oriented" (Patton, 1987, p.19).

A qualitative approach may provide the understanding of teachers' reasons and intentions in order to obtain comprehension of the "whys" of the events and thus the effects of the programme on the teachers who attended it. Qualitative research has the aim of "understanding experience as nearly as possible as its participants feel it or live it" (Sherman, R. and others, 1988, p.7).

Burgess (1985) indicates several important characteristics associated with qualitative work in the field of education. Some of these are presented in this study:

> "The focus is on the observed present, but the findings are contextualized within a social, cultural and historical framework.
>
> The research is conducted within a theoretical framework. While there may only be a small number of questions to orientate a study, further questions may arise during the course of investigation.

> The research involves close, detailed intensive work. The researcher participates in the social situation under the study.
>
> Unstructured or informal interviews in the form of extended conversations may complement the observational account.
>
> Personal documents may give depth and background to the contemporary account" (p.5).

In this study data was gathered, by means of field notes, within the schools through participant observation, when teachers were working with their students, and in the Higher School of Education, when they were attending the formal training sessions and project meetings. Casual conversations with teachers in natural settings provided information to inform the organisation of formal interviews in greater depth, "suggesting further discussion of a particular issue" (Jorgensen, 1989, p. 85).

This methodology was chosen to give a holistic approach;

> "The aim of qualitative research is not verification of a predetermined idea, but **discovery** the leads to new insights. Thus the qualitative researchers focus on **natural settings...** Experience is to be to be taken and studied as a **whole**, or holistically. One must attend to all features of experience" (Sherman, 1988, p. 5).

Teachers worked within their schools and they functioned as a group, since they were linked to the MINERVA project and they were developing common projects. A qualitative approach allows a study of the teachers to give consideration to social aspects. Jorgensen (1989) writes that "case studies stress the holistic examination of a phenomenon, and they seek to avoid the separation of components from the large context to which these matters may be related" (p. 19).

This teacher training programme had some innovative features inasmuch as it introduced a new instrument, the computer as a pedagogical resource, and it was a flexible programme, not completly defined at the begining. Patton (1987) argues that "the qualitative-naturalistic approach is thus especially appropriate for programmes that are developing, innovative, or changing, where the focus is on programme improvement, facilitating more effective implementation, and exploring a variety effects on participants" (p. 18).

The results of this study can also provide understanding of weaknesses and possibilities for in-service teacher training programmes for further improvements in the future. Patton says that "a qualitative case study seeks to describe some unit in depth, in detail, in context, and holistically" and he adds that:

> "Cases studies become particularly useful where one needs to understand some particular problem or situation in great depth, and where one can identify cases rich in information - rich in the sense that a great deal can be learned from a few exemplars of the phenomenon in question. For example, a great deal can often be learned about how to improve a programme by studying select dropouts, failures or successes" (p.19)

Parlett and Hamilton (1972) consider that to evaluate an innovatory programme it should be viewed as an illumination, as "the introduction of an innovation sets off a chain of repercussions throughout the learning milieu". They state that, "different techniques are combined to throw light on a common problem". Observation, interviews, questionnaires and analysis of documents and background information are all used to help "illuminate" problems, issues, and significant features. These authors argue that:

> "The aims of illuminative evaluation are to study the innovatory programme, how it operates, how it is influenced by the various educational situations in which it is applied; what those directly concerned regard as its advantages and disadvantages,...and,in addition, to discern and discuss the innovation' most significant features, recurring concomitants and critical processes. In short, it seeks to address and illuminate a complex array of questions" (p. 10).

Patton (1987) advocates qualitative methods because they "emphasise the importance of understanding the **meanings** of human behaviour and the social context of social interaction", and then qualitative data can be collected by "participant observation, in-depth interviewing, detailed description" (p. 20).

4.3. THE ROLE OF THE RESEARCHER IN THE TEACHER TRAINING PROGRAMME

I took a dual role during the first year of the study, as I was at the same time the researcher and one of the teacher educators. Working together with the teachers over two years, participating in part of their life's work, a close relationship was established between me and the group of teachers under the study. "Although participating as a researcher places the observer on the margins of human action, it rarely is possible to remain uninvolved with the insiders" (Jorgensen, 1989, p. 58). In spite of the advantages of participatory observation, it was my concern to avoid losing objectivity. I knew that I had to analyse all the direct observations with criticism. The field notes were descriptive, and the casual significant teachers' statements were noted as soon as I could, trying to write in the same way that teachers had spoken, and not in my own words.

Besides me, other teacher educators were involved in the conduction of the in-service programme. They knew the main objectives and the structure of this study. Regular meetings were held with me in order to decide the training activities. The teacher educators were asked to write statements about teachers' behaviour which they thought to be significant, as well as descriptions of significant happenings during their visits to the schools.

4.4. COLLECTION OF DATA

Due to the exploratory nature of this study I did not have a well defined research plan at the beginning. Throughout the research the data collected influenced further data. As was summarily displayed in table R, data was gathered by means of interviews, questionnaires, field notes of informal conversations and participant observation in natural settings, as well as through the analysis of some of the materials produced by teachers. Examining teachers' attitudes through different sources of data provided greater reliability of conclusions (Woods, 1986).

The need to study teachers' reactions and opinions during a long period of time allows for the use of different instruments, which is one particular aspect of "triangulation". According to Manion and Cohen, (1984) "triangulation can be an useful technique where a researcher is engaged in case study". These authors note that triangular techniques "explain more fully the richness and complexity of human behaviour by studying it from more than one standpoint" (p. 254). Another type of triangulation that I used, was to compare my data with the data collected by my colleagues on the training team.

4.4.1. The Questionnaires 1, 2, and 3 (table R)

All the 29 teachers were given three questionnaires, at the end of each phase of the programme. In these questionnaires (annex A, B, and C), teachers were asked to give their opinions about the development of the training programme, the educational role of the computer from the teachers' point of view, as well as teachers' needs for further activities. The questionnaires had three main general objectives: (a) to provide information in order to adapt and to develop the programme itself; (b) to gather some information about the impact of the programme on teachers, mainly relating to the role of the computer in education; (c) to provide a source from which issues could be identified as a basis for designing the interviews.

The return rate of the responses were: first and second questionnaires 86%, and the third 76%. In all the questionnaires anonymity was respected.

4.4.2. The interviews (table R)

Two kinds of interviews were used: semi-structured interviews (1, 2, 3, 4, and 5, see table R) and the unstructured ones or informal conversations. Annexes F, G and H are the semi-structured interview schedules. The individual semi-structured interviews (3, 4, and 5) were done by me and they were taped; afterwards they were written and translated in English, respecting the terms of teachers' speech. Three of these teachers showed some concern about taping their interviews, so these were written respecting the teachers's own terms.

During the first school term two group interviews 1, and 2 (annexes D and E) also took place which will be described in detail in the following paragraph.

There was a need to do some informal interviews, since this study required gathering information when things were happening, clarifying some issues which were not thought of before, or about which I had a general idea, but that arose during school activities or during the training. Hitchcock and Hughes (1989) note that "conversations are of course a major element in any kind of ethnographic field research" and they continue:

> "The unstructured interview allows the interviewer greater scope in asking questions out of sequence and the interviewees of answering questions in their own ways" (p. 87).

Informal conversations with teachers occurred throughout the two years. From these conversations, field notes were taken. These kinds of conversations also took place with some students during direct observation. However later on these data were omitted as the results did not appear to be providing significant information in terms of objectives of this study.

4.4.2.1. Work project interviews (1, and 2, table R).

During the first phase of the programme teachers developed a work project as is described in chapter three. This included two group interviews carried out by me in the presence of the other teacher educators, who could intervene when they thought it to be useful. The first interview (annex D) took place in the beginning of the phase of gathering data by teachers and the second one at the end of the data collection and just before the presentation of the projects. These two interviews were very open-ended ones and they had the following objectives:

To help the teachers to develop their field work ascertaining their difficulties in doing so;

To provide an opportunity of reflection with them upon the dynamic within the group; and

To suggest some ideas for resources and for the presentation of the final products.

Twenty minutes before these interviews teachers were given a written paper with the questions of the interviews (annex D and E). They were asked to think about these individually, and then to discuss them within the group. When I began the interview I asked teachers to talk about the main difficulties that they were encountering in field work (first interview), and about the presentations which they would be making (second interview), and I let them speak freely. When I felt that it was opportune I approached the questions of the interviews. "Participants get to hear each other's responses as they hear what other people have to say" (Patton, 1987, p. 135).

These interviews were not taped: notes were taken written in Portuguese and then translated into English.

Teachers' groups were formed according to the schools to which they belonged, which were coincident with the projects on which they were engaged.

4.4.2.2 The Semi-structured interviews

In spite of there being a schedule for the interviews, they were carried out taking into account the answers that teachers were giving to the questions; this means that the interviews were not closed ones, but following up with additional questions, when it was necessary to probe some answer. As Patton, (1987) states:

> "The purpose of interviewing is to allow us to enter the other person's perspective,... depth interviewing probes beneath the surface, soliciting detail and providing a holistic understanding of the interviewee's point of view" (p. 108).

Three open ended semi-structered interviews (annex F, G, and H) were carried out during this study, the first when the programme was over. The other two interviews (only for the mathematics teachers) were carried out in the following year when it was supposed that teachers would be more reflective and able to stand back.

4.4.2.2.1 The first interview

The first formal interview (annex F) took place at the end of the programme (July, and September of 1988, since the teachers' holidays did not coincide) for a sample of nineteen of the whole set of the teachers. The criteria for the selection of this sample was: to have all the nine Mathematics teachers, as they would be the subjects of the study of the following year; to have a significant part of the primary school teachers - 4 from the whole set of five, one from each primary school (3); one from the special school for boys, and 6 teachers covering all the curricular areas, which are described in chapter five. These six teachers were chosen from amongst those who attended all the teacher training sessions.

The objectives of this interview were:

1) To gather information about the teachers' opinions concerning the influence of the various parts of the programme on their professional practice.

2) To understand how the teachers viewed the use of computers within school, after the first year of experience.

3) To identify some issues in order to deepen the further research work.

The first objective attempted to understand the impact of the teacher training programme, from the teachers' point of view and in their own terms. These impressions were gathered quickly, since teachers were still much engaged in the happenings of the school year.

The second objective was concerned with some pedagogical issues related to the use of computers in schools, and through the teachers' answers to study the aspects of which teachers were aware after this experience.

The third objective was to prepare the development of the research itself in order to focus the further gathering of data on aspects which may not have been thought of in advance. The content analysis of teachers' answers showed some new aspects, providing information to allow further probing in later questions.

4.4.2.2.2. The second interview

The second interview (annex G) took place during the second school year, as it is showed in table R, for the eight mathematics teachers involved.

This middle term interview was carried out with the following objectives:

1) to gain information concerning teacher's thinking about their own experiences with computers on both curricular and extracurricular activities with students.
2) to gather teachers opinions related to their own understanding of their possible changes towards the learning process.
3) To use the analysis of these interviews to structure the following ones in a deeper way.

4.3.2.2.3. Third Interview

The third formal interview (annex H) took place in October 1989, at the beginning of the third school year in which these teachers were working on the MINERVA project. The reason for this date was because it was expected that teachers could look back on the previous school year and they would begin their third year of working with new ideas for the work to be developed with computers. All the 8 Mathematics teachers were interviewed.

The objectives of these interviews were to explore and to adjust the categorisation already delineated, gathering more information about teachers' views concerning the introduction of computers in the mathematics curriculum as well as in the computer club. It was intended to find out teachers' opinions about both the role of the teacher and student in mathematical activities, and the importance of the computer in the development of student knowledge and autonomy. It was also intended to gain more insights into teacher's perspectives of their own development.

Teachers were asked to imagine that they all had the resources they needed in order to work with students using computers, and then to build up a picture of desirable student activities, both within the classroom, and the computer club. They were also asked about the influence of all the work that they had done over the two years, helping then to clarify their role both as an educator and as a mathematics teacher.

4.4.3. Observation

During the running sessions, seminars and workshops, as well as during the presentation and exchange of experiences and evaluation sessions, notes were written concerning some teachers' statements or some relevant features. Also the other teacher educators were asked to take notes of anything which they thought to be important as well as focusing on some aspects selected by me, following a discussion session with all teacher educators involved. During the first year there were visits to teachers' schools, observing teachers working with students in order to observe the ongoing projects. Three of these visits were part of the programme itself as was explained in chapter three. Other visits were carried out by me and by teacher educators who were giving direct support to teachers. These visits are also described in the previous chapter. These visits were a good opportunity to see teachers in action, and follow the development of their projects in their natural settings.

During the second year mathematics teachers were observed in their schools both in curricular and extracurricular activities. Each mathematics teacher was observed by me in both computer club and classroom settings three times each. Annex MT (Mathematics teachers) describes whether these teachers had worked in the classroom, in the club or both. Also, in annex O, there is is a transcript of an example of a computer club observation.

All the observations were naturalistic ones, describing all the events of the classroom or computer club work. After each observation I developed a conversation with the teachers about what was happening in students' work, and we talked about students' behaviours, commenting on some of the events that had occurred.

4.4.4. Documents

The documents analysed were:

1) Teachers' reports of the work project developed during the first phase of the programme;

2) Work developed with students using computers;

3) Worksheets produced by mathematics teachers for students for both classroom work and to support students' activities in the computer club during the second year.

4.5. DATA ANALYSIS

Most of the data analysis took place alongside data collection. This continuous process allowed me to delineate some emerging categories and to define the questions to ask during later interviews. Also throughout the research, the analysis of data collected influenced aspects to be selected on relevant literature, which review continued alongside field work. In turn, literature review had effects on the development of the research, mainly in the analysis of data and subsequent categorisation of teachers (e.g. Bernstein' s theory in chapter 6).

According to Glaser and Strauss (1967), in qualitative research the emphasis should be on discovery rather than testing of theory. The process of theorising grounded in data "becomes particularly salient at the stage of interpretating and integrating data" (Le Compte and Preissle, 1993, p. 278).

> "The goal of grounded theory is to generate a theory that accounts for a pattern of behaviour which is relevant and problematic for those involved". (Strauss 1987, p. 34).

As categories emerged from the fieldwork, they were being refined during the research. Strauss (1987) uses the term, "code category" to designate a category that is central to the integration of the theory. These categories are important as other categories are related to them and through these relations it is possible to integrate the theory and "rendering it dense and saturated as the relationships are discovered" (p. 35).

In the beginning of the second year of the field work, the analysis of the data gathered during the implementation of the teacher training programme provided provisional categories, which were important to make distinctions and comparisons among teachers, as well as to raise "generative questions" (Strauss 1987) and to develop further fieldwork. The new data, observed events, interviews and the analysis of materials produced by the mathematics teachers yielded the establishment of connections and the defining of three categories of teachers (in chapter six).

In this study the constant comparative method was used to generate categories grounded on data. This method is a formalised process of comparing, contrasting, establishing linkages and relations, which provides a systematisation and abstraction (Le Compte and Preissle, 1993).

Data gathered from the interviews was analysed using content analysis. According to Bardin (1977) the content analysis aims to understand the speaker's message through their words, looking for common themes approached and their frequencies. This analysis was done by reading the interviews in order to capture the main aspects addressed by teachers in their discourse. This process enabled me to begin delineating broad categories, containing some ideas concerning the question approached. Spradley (1979) calls these categories which include other categories, a domain. As he states "all the members of a domain share at least one feature of meaning" (p. 100). The next step concerned a deeper analysis of teachers' answers inside each broad category, which enabled me to obtain categories included in each of these categories, examining similarities that existed in their answers. This content analysis was carried out in two different ways: teacher by teacher, and question by question. The first type of analysis enabled me to delineate each mathematics teacher's profile (see annex MT), which was enriched with the observations, analysis of documents and informal conversations. By means of this vertical analysis it was possible to understand some differences and similarities among teachers. This process necessitated reading several times the interviews.

During the first year the focus was more on the programme than on individual teachers, and during the second year the focus was more on teachers as individuals. Writing a description of each mathematics teacher (in annex MT), provided me with a more complete and global view of each teacher's profile, since I had to read all their statements, and my notes of observation again as well as to analyse all the documents they produced for their students. Descriptive categories were organised around common features or characteristics by comparison, through teachers' responses and opinions and work developed with students. Through the comparative method it was possible to obtain a constant comparison among categories which provided the development of concepts and their linkages in order to capture both variations and similarities (Le Compte and Preissle, 1993).

This process of analysis during data collection provided a permanent reflection upon what was happening, refining further by fieldwork. It was not possible to have a complete preestablished plan of action; even as the programme was not completely defined in advance. This is supported in literature for instance by Le Compte and Preissle (1993), who state that:

> "Because ethnographers emphasise meaning as defined by participants, they cannot choose all the data collection methods necessary for a study in advance of field work" (p. 238).

The whole process followed in this research provide me wt a deeper understanding of what was happening and after some time led to the setting up of more questions. At the beginning, I aimed to gain understanding about the impact of the in-service teacher training programme on teachers' attitudes towards the teaching/learning process and their pedagogical practices, and about the role of the computer in this process. During the development of the programme, when I began analysing and interpreting data, further questions, which are stated in the beginning of this chapter, were also raised: teachers' attitudes relating to the use of computers in schools; teachers' attitudes concerning both the teaching and the student learning process; and teachers' views about their own development, were made clear to me. In summary the method I used was to observe, to hear, to record, to write, select examples of materials produced, to interpret, to reflect, to read relevant literature; all this in a spiralling revisiting earlier findings in order to acquire ever deepening sense and insight into the proposed questions.

The following chapters are organised to address the three questions of this study. Data and results presented does not necessarily follow a chronological order. The next chapter describes and analyses the first reactions to the programme (Work project), the first work with students that teachers developed during the development of the programme and their first opinions regarding the use of computers in schools. The sixth chapter concerns the mathematics teachers who were studied in more depth, regarding the teaching/learning process, and also related to the pedagogical use of computers. The seventh chapter refers to teachers' views on the influence of the programme on their professional development, and their opinions about the different components of the programme.

CHAPTER 5

TEACHERS' INITIAL ATTITUDES AND INVOLVEMENT WITH COMPUTERS DURING THE PROGRAMME

5.1. INTRODUCTION

This chapter is divided in three major parts. The first concerns the teachers' perceptions about computers in education at the beginning of the teacher training programme. The second analyses the teachers' reactions to the main proposals of the programme, the work project (first school term). The third refers to the practical work with computers during the rest of the programme, when they started working in the schools with students on computer activities, as well as teachers' views about educational potentialities of computers.

The development of teachers' attitudes towards computers, at the beginning, during the programme and in the end, will be discussed in chapter six. Also these findings and those of chapter seven will be discussed together in chapter eight.

5.2. TEACHERS' INITIAL PERCEPTIONS ABOUT COMPUTERS IN EDUCATION

At the beginning of the in-service teacher training teachers were asked to write a short sentence expressing their views and opinions towards computers as an educational tool. This was responded to anonymously by 27 of the teachers (the other 2 did not respond as they had worked with students in computer activities the preceding year).

All teachers considered that computers would change or improve something in education. However, two main categories became apparent, one considering that computers would foster something in their professional development with the consequent benefits to their students, the other referring to the computer an innovator agent, without reference to the teacher's intervention. Subcategories were identified within these two categories as shown in table A.

Table A: Teachers' sentences on computers as an educational tool

	With teacher's intervention	Without teacher's intervention
Innovate and improve the teaching process	13	
Personal development	6	
Foster students' capacities	5	1
Develop student motivation towards the school	4	5
Improve student learning and decreased school failure	3	5
Student Socialisation	1	2
Nº of teachers	18	9

Some teachers (13) referred to more than one aspect of these subcategories.

To innovate and to improve the teaching was the aspect hat was indicated more frequently by the teachers. One teacher rote that "...to learn to adapt my teaching and my action in chool to the new needs of society". Another stated that "I want o look for new ways of working, creating new interests to the eaching and to myself". More related to new ways of teaching and students improvement; a teacher wrote: "I hope to find processes which can help students with learning difficulties".

Teachers who referred to personal gains showed a certain fear of becoming outdated if they did not learn about computers, as for instance this teacher who wrote in short sentences "Learn. Do not stop. Do not be passed by the students", and she added: "Improve the education. Innovate." Two teachers used the following statement to say the same idea "does not crystallise". Another stated "To learn is to deny the effect of aging".

Another aspect pointed out by teachers was the increase of student motivation towards the school with computers. However (see the table A), there were two kinds of teachers' statements, those who thought that the computer by itself could motivate and those who considered that through the computer new activities should be developed and so create new interests in students. "To create new learning situations which apply for a student involvement" or "the computer is a new thing for students and they become more motivated towards learning" are two different ways of seeing the role of computer as a motivation factor in the learning process*.

The role of the computer in developing students' capacities for creativity and reasoning was also noted by some teachers as or example this sentence showed: "I hope to find new ways of eaching that students will be enthusiastic about and that can evelop their capacities such as creativity".

Some teachers seemed concerned with school failure and elieved that the computer could help students in the learning of the curricular subjects, as this teacher who wrote: "Perhaps the computer solves some learning problems to which even we do not know the solution". Giving the emphasis to the teacher's role another teacher mentioned: "My expectations are to know the potentialities of the computer and after that, to realise a different way of working, more positive from the point of view of the learning of my pupils".

Finally, three sentences referred to questions of socialisation, as this teacher who mentioned "... my role of educator does not allow me to crystallise, as I have the responsibility of facilitating the child's integration into society".

In summary, teachers saw computers as useful, expressing positive perceptions related to their introduction in schools. Eighteen teachers seemed to hope that computers could be a factor in changing or innovating something as people and professionals, and nine teachers showed themselves to be frustrated with students' learning and their involvement in the work of the school and seemed to believe that the computer could improve something, without mentioning their intervention.

These results are an indicator that all these teachers had a positive predisposition at the beginning of the programme. However, they were not very specific concerning the role of computers n what the students gained, which seemed to show a lack of nowledge of educational software as well as its use in students' earning.

.3. TEACHERS' REACTIONS DURING THE FIRST PHASE OF THE PROGRAMME, EN THE WORK PROJECT WAS DEVELOPED.

During the first phase of the programme teachers (see chapter three) continued the initial technical training and they developed a work project based on a problem or theme that they had interest in studying related to the introduction of computers in schools. At this stage teachers had already been informed about the objectives of the Minerva Project as well as the main proposals of the node: to begin the computer activities with students as soon as possible, that was during the second school term; to organise the computer club in their schools; and to begin their colleagues' stimulation concerning the use of computers in the school.

The project work had several major parts: choice of the problem, field work, data organisation, presentation and evaluation. During field work it was suggested that teachers should go to visit schools where computers had been already introduced, to see computer clubs and observe students in action, to interview teachers and students, to look for bibliography, documents or other materials, or other sources which teachers thought could be useful in order to study and "illuminate" the theme chosen.

5.3.1.The choice of the problem

Six groups of teachers were formed in order to choose the theme to study. They formed the groups according to the school they belonged to. The six primary teachers, who were from three different schools, stayed together.

Teachers were asked to discuss within each group what would be the more important problem to study, and after that to present it to the whole group, justifying the reasons for their decision. This task was easy to accomplish, and the teachers soon decided the themes, which are also referred in chapter three. The primary school teachers chose to know about LOGO in primary curriculum. Two groups of teachers of preparatory schools decided to work on the organisation of computer clubs, another two chose to study issues related to the involvement of their colleagues in the school, and one group preferred to investigate about the use of computers in the mathematics curriculum through diversified classroom activities.

Teachers' arguments to justify the choices indicated that they were influenced by the first tasks that they suggested to them, which were to organise the work with computers in their schools as well as to stimulate the involvement of their colleagues. The two teachers who had worked in the Project the year before, chose to study and investigate independent work in the mathematics classroom, as one of them said "we have already organised the computer club and developed computer activities in extracurricular activities, now we want to do something within the classroom in the Mathematics curriculum". It was also expressed by one of the primary school teachers that: "LOGO seems to have great potentialities for children of these ages".

5.3.2. The development of the projects

The two interviews (annexes D and E) of the teachers with me and the other teacher educators, carried out during the development of the projects and completed before the teachers presented their works, formed part of the process of the work project methodology. They were mostly about the process and the contents, and they had the intention of giving feedback to the teachers and to make them to reflect about what was going on.

All teachers declared that they were working in cooperation, the tasks having been distributed among them. However teachers from one school (School A) seemed not to be very comfortable during the interview, two teachers were missing, and sometimes they there was no agreement among them concerning the work, which revealed that they had not worked as a group. Also the work developed was poor, revealing a lack of discussion among the different participants. Teachers in another two groups pointed out some difficulties they were faced with, which were due to the fact that their schools were not accepting them very well (schools C and D), as expressed by one teacher: "We feel some hostility from some of our colleagues in school. We have to justify what we are doing", and other teacher said: "I feel a pressure to show work, you know there are a lot of teachers against the computers".

During the first interview teachers showed a deeper understanding of the question they were studying, which seemed to come from the field work carried out so far, and the discussions among them. As one teacher stated about the field work: "Now we ave a lot of problems to solve: how to decorate the room, how o do the pupils' selection to work in the club, what timings, hat kind of work with students and with teachers,...it was mportant to talk with people who have already had the same roblems and to see different points of view in order to solve hem."

At the beginning, teachers in two groups showed some insecurity about their field work. This fact was noted by such expressions as "I never did this before"; " Do you think that teachers will agree to show us the work they are doing?"; "Is this necessary?".

During the development of the work some teachers showed greater confidence and enthusiasm (this was mainly expressed in the second interview). However some teachers from two preparatory schools and two primary school teachers showed that they did not feel very comfortable, as one teacher put it "we are doing the work project without knowing very well what it is".

Teachers were asked to write a brief report about their work which was delivered to the whole group at the beginning of the final presentations. The primary school teachers stated that they would prefer just to present the work and not write the report. These reports already written in word processing described the main activities they developed and the conclusions. Teachers presented their works using several kinds of instruments, materials such as overhead projector, computer, and posters. After the presentation of each group, the other teachers had ten minutes to ask questions of their colleagues, which they thought to be necessary to better understand the work presented.

The teachers seemed involved and participative in this final session, except those of school A, cited above, those who had never showed any interest in this kind of work. The presentation was done just by one of the teachers of the group and their report had only one page. As they watched to the other groups' presentations they felt the need to justify themselves and they explained that they had problems of timing in meeting together in order to discuss and prepare the work.

5.3.3. Teachers' evaluation of the work project

At the end of the final session teachers were asked to make some verbal comments about the work of these months. There were three categories of comments:

1) Teachers who expressed the opinion that it was worthwhile, but felt insecure about computer knowledge, for instance this statement:

> "I really enjoyed this work, we had very good moments together, I liked to see the work that other schools were doing, now we have all prepared, the computer club is almost organised,... I feel a little anxious as I know that I have to work with the students and I need to practice a lot with the computer. We needed more time available".

2) Teachers who considered that they had never thought themselves capable of accomplishing the work, but who showed themselves to be quite satisfied; "now I feel that it was very important to have done it, as I had other experiences, and I could know my colleagues better" as a teacher said.

3) Teachers who did not understand why they had to develop this

ind of work when they had so much to learn about computers. hese six teachers expressed this opinion in a very polite way, s for instance this one:

> "When I went on the Project I imagined a different training, I recognise that this was useful, but perhaps we have lost time now in the beginning with the field work for instance...Anyway I would like to have more technical training".

Later on, teachers were asked to evaluate this part of the rogramme, by means of a questionnaire (see chapter seven), and ten teachers indicated the work project as having made important contributions to the use of the computer as a pedagogical instrument, and ten considered it to have made moderate contribution.

During all this process a great majority of these twenty nine teachers showed some anxiety related to this kind of work, perhaps because they were not used to having to develop practical work during the training courses they had already attended on other occasions, and also because they felt the need to dedicate more time to the technical training. However, in the final session when they could show the other colleagues and the teacher educators the final products, in general they showed satisfaction. Probably they recognised that they had fostered their understanding concerning some aspects which they would have to develop in their schools, using computers, such as the organisation of the computer club, and how to begin the work with their students.

.4. TEACHERS' FIRST EXPERIENCES WITH STUDENTS IN COMPUTER ACTIVITIES.

During the second and third phases of the programme which ccurred at the same time as the two last school terms, teachers egan to work with students developing computer activities in heir schools, as had been agreed at the beginning of the programme. Teachers chose the work that they would like to develop with students.

The main activities are summarised in the following table. At the end of the school year all teachers presented their work and projects to the whole group involved in this course (see agenda of the first phase, in chapter 3). Teachers were stimulated by me and other teacher educators to include during their presentations the process experienced, mainly difficulties they had encountered during the development of the activities. This session was followed by a work session where teachers were asked to think about the projects which they wanted to develop in the next school year.

able B: First experiences developed with students in activities sing computers

School	Activity/ Project	Classroom Club	No of Teachers	Software
Prep. B	Geometry (Patterns)	Classroom	2 (Maths)	LOGO
	Portugal and EEC	Classroom	1* (S.Studies)	Gem Paint
Prep. D	Highway in town	Club	2 (Maths)	LOGO W. Proc.
	EEC Countries	Club	2 (Maths)	Spread-sheet
	Portugal and EEC	Classroom	1* (S.Studies)	G. Paint
	Fables	Club	1 (English)	W.Proc.
Prep. C	Geometry (Polygons)	Club	1 (Maths)	LOGO
	School Journal	Club	4 all**	W.Proc. G.Paint
	Educational environment	Club	4 all**	LOGO W.Proc. G.Paint
Prep. E	Geometry (Shapes)	Club	2 (Maths)	LOGO
	Study of Earth	Club	1 (N. Science)	PC Quest
	Patterns Painting	Classroom	1 (V. Educa.)	G.Paint
	Traditional Stories	Club	2 (History, V.Educa.)	W.Proc. G.Paint

able B: First experiences developed with students in ctivities using computers (cont.)

chool	Activity/ Project	Classroom Club	No of Teachers	Software
rep. A	Numerical Expressions	Club	1 (Maths)	(a)
	Portugal and EEC	Classroom	1* (S.Studies)	G. Paint
	Stories	Club	1 (English)	W.Proc.
	Drawings	Club	2 (Craft)	G.Paint
Prim. H	Stories and Drawings	Classroom	4 (Primary)	LOGO W.Proc.
Prim. F	Texts and Drawings	Classroom	1 (Primary)	LOGO G.Paint W.Proc.
Prim. G	Texts and Drawings	Classroom	1 (Primary)	LOGO G.Paint W.Proc.

* These three social studies teachers had the same project and they worked together.

** All teachers of this school who attended the programme were involved in this project;(Mathematics 1 , Visual Education 1, Craft and Design 2).

(a) This mathematics teacher asked the teacher educator to do a program for her students to practice numerical expressions.

Most of teachers of preparatory level worked in the computer club on both curricular and extracurricular activities. Six worked within the classroom, approaching curricular subjects using computers (4 Social Studies teachers and 2 Mathematics eachers). All the primary school teachers, as these schools sually do not have computer clubs in their schools, only deeloped activities in the classroom.

he analysis of this work showed me different aspects:

. The role of the computer in all these activities;

. The role of the teacher and the students during the choice, nd the development of the projects or activities; and

3. The kind of projects, that means if the projects were only to teach curricular subjects or if the main objective was to involve the students in some kind of an open project, with a purpose and including interdisciplinary activities.

There were four open projects: EEC countries (school D), School journal and Educational environment (school C), and Traditional stories (school E). All these projects involved two or four teachers working together, and the students had an active role in their development. However the choice of the theme was a teacher's choice, with some discussion with students. Students also had an important role during the development of the projects. All these projects had a final product as a result; the journal, a book with the stories illustrated with drawings done with the GEM Paint, an exhibition to the school (The educational environment), and a report with information about the EEC countries made on a spreadsheet.

The students of the primary school F also developed a project telling a story created by them and illustrated with drawings done in LOGO.

The third aspect, referred to above, was the one that determined the role of computer and the level of the students' autonoy during the development of the activities. In these five rojects the computer was a resource to accomplish the final roducts, but the emphasis of the students' work was the search or information, the discussion provided between them and with he teachers. In the cases of classroom work, and the other ctivities mentioned in the table, the work on computer was the main students' activity. For instance, during the classroom work, teachers defined students' activities in advance and the students had few level of decision.

Teachers were asked, by means of a questionnaire (annex B) if the work that they were developing with the students in their schools corresponded to their expectations and why.

All teachers from Primary School (6) reported that the work with the students exceeded all expectations:

> "The students saw in the computer a way of quickly accomplishing certain tasks and I realised that it develops both their concentration and creative capacities";

> "It was beyond my imagination - both for the interest shown by the children and for their intellectual engagement and behaviour toward the computer. All difficulties were widely compensated. Children distinguish between games at home with the computer and the work in the classroom; they feel that the computer helps them working in the classroom".

Teachers of Preparatory Schools, did not show so much enthusiasm. However twelve teachers said that the work with the students was corresponding to their expectations (3 of them said it was beyond their expectations); five said "no" and one of them said "It is and it is not; it is corresponding because of the articipation, interest and commitment of the students in the ctivities; it is not corresponding because the time is too short or this kind of work". Teachers who answered negatively justiied their answer with the lack of computers in schools.

.5. TEACHERS' VIEWS ABOUT THE COMPUTER AS AN EDUCATIONAL RE-OURCE.

Teachers had developed activities using computers during two chool terms (from January to July). At the same time they were attending the course (see chapter three). During these months teachers were asked to answer formally a middle term questionnaire (annex B), the results are in 5.5.1., a questionnaire when the programme was over (annex C), and an interview (annex F), in 5.5.2. These instruments had among other objectives (see chapter 4), to complete the information gathered by means of informal conversations with teachers, concerning their views about computers as educational resources, after a considerable time of work with the students. In 5.5.3. These results with those of initial teachers' opinions (see 5.2.) will be discussed in order to compare them, and to understand the effects of practical work, and the training, on teachers' views about computers in education.

5.5.1. Teachers' views about the computer as an educational resource, after a school term of work with the students.

Teachers' answers to this questionnaire, showed mainly three kinds of statements related to: students' gains, teacher/student relationships, and teachers' gains.

Eleven teachers focused on the opinion that the work with computers could be more motivating and interesting, engaging the students towards the school, developing their creative skills, and fostering the work in a group. Also related to the relation between teacher and student, and the interdisciplinarity these teachers wrote: "It makes my work more interesting and it facilitates the contacts with students, and enables the development of team work", and "It enabled a very positive relationship among students and teachers, a dynamism in school and it helped to overcome barriers of disciplinary frontiers".

Teachers who focused on personal aspects , pointed out the following: to reflect about change and how to proceed in order to change, personal and professional enrichment, more personal motivation towards their work, the need to answer to new pedagogical questions.

Six teachers also mentioned the possibility that the school might become more dynamic and the fact that the work which they were developing could motivate other colleagues to "follow the example" and also begin working with computers.

5.5.2. Teachers' views about the computer as an educational resource, at the end of the school year.

At the end of the school year, Teachers' opinions concerning the potentialities of computers in education were gathered by means of a questionnaire (annex C) and an interview (annex F) as well as through informal conversations related to the work that was going on in the schools. By the answers to the questionnaire

25 teachers responded), the main aspects referred to were crea-ivity, motivation, team work, student autonomy, and research kills, as is displayed in table C.

'able C: Computers in education: teachers' opinions

[ain potentialities of computers	No of teachers (out of 25)
)evelopment of creativity	15
[otivation towards learning	13
:ooperation and team work	13
;tudents' autonomy	9
₹esearch skills	8
;tudents' persistence	6
₃etter student learning	4
;reat rigour of reasoning	1
₹eflection habits	1
;tudents' responsibility	1

The analysis of the responses to this questionnaire showed :hat teachers considered as the most important potentialities of :omputers, the stimulation and development of students' crea-tivity, the capacity for working in a group, and the increase of students' motivation towards school work. Also eight teachers referred to the development of research skill as the main aspect of computers in schools and nine answers referred to the foster-ing of students autonomy: " The work with computer contributes o greater student autonomy and at the same time to a greater ense of help among students". To clarify those aspects some uestions were asked to teachers (annex F), during the interview arried out in the end of this school year.

The following tables displayed information concerning teach-rs' opinions about computers in education through several ques-ions during this interview. In these three tables only the art of the response to these questions related to students' benefits is shown.

Table D: Teachers' responses to the question: In your opinion what are the main aspects that can be changed at school with the introduction of computers in Education? .

Teachers' responses	Frequencies (out of 19)
Student aspects	
Leaning by interdisciplinary activities	4
Foster independent work by the students	4
Cooperative student work	4
More engagement towards the school work	3
Develop logical and reflexive reasoning	3
Foster an attitude of discovery by students replacing the passive one	2
Allow the respect of each student's pace	1
Students' learning may not be established in advance	1

able E: Teachers' responses to the question: Are you interested n using computers in curricular activities?

eachers' responses Reasons for the "YES")	**Frequencies** (out of 19)
Students' aspects	
evelop some students skills (reasoning and reativity)	5
tudents become so interested and pleasant hat they are ready to learn	4
mprove the learning of some concepts	3
repare towards the future since it is a ew technology	1
Foster interdisciplinarity activities	1

Table F: Teachers' responses to the question: Do you think that school failure can decrease with the introduction of computers in schools?

Teachers' responses: (reasons for "YES")	**Frequencies** (out of 19)
Student aspects	
Motivation for learning	11
Development of student reasoning	4
Students gain self-confidence	3
Better adherence to school work	2
Foster competition among students	1
Challenge for the students	1
Promote trial and error experiences	1
Students can use previous knowledge	1

Analysing all the answers, I could understand that teachers entioned students gains both in social-affective and in cognive levels. The main students' gains cited by teachers were:

ffective aspects: student motivation for learning, independent and cooperative student work, students self-confidence, better adherence to school work, fostering an attitude of discovery by students.

Cognitive aspects: developing of logical, reflective reasoning and creativity, improving the learning of some concepts, learning by means of interdisciplinary activities.

Almost all teachers related both cognitive and affective, aspects, mainly relating motivation to students' success in learning, as for instance this statement: "student learning process becomes more enticing, and so providing a better student learning".

These results reveal that teachers viewed computers in schools as a significant tool for students, specifying aspects which were not pointed out at the beginning of the programme, probably influenced by the work developed so far. An example were these two statements: "They are going to construct the things by themselves, and from the work they do they learn", and "the passive role of the student is replaced by an attitude of discovering and greater mental activity". These findings will be discussed in the end of this chapter, and in the following chapter, together with those of the second year of this study, when a deeper analysis was carried out with the mathematics teachers.

.6. HOW TEACHERS VIEW THE STUDENTS' MOTIVATION TOWARDS COMPUTERS

The role of the computer in the student motivation towards chool was referred to several times by teachers;

In order to explore the student motivation issue, that a arge number of teachers, directly or indirectly, referred to everal times, teachers were asked in the interview (annex F) bout their opinion concerning this aspect through this question: hy do you think that students enjoy working with a computer?

The answers to this question were very diverse. Teachers ave more than one reason for students' positive attitude towards the work with computers. The results are shown in Table G.

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able G: Teachers' responses to the 1st question: Why do you ink that students enjoy working with the computer?

eachers' responses	Frequencies (out of 19)
tudents aspects	
tudents have the opportunity of eveloping their own ideas	7
tudents feel success and pleasure with omputer projects outcomes	7
Challenge for students	6
Autonomous and power feelings	5
It is connected by students with playing	5
It is not connected by students with classroom work	3
Students use their imagination and creativity	2
Students can manipulate	2
Students' pace is respected	1
Others aspects	
Novelty	10
Up-to-date	3
Social promotion	3
Future utility	1

Most of the teachers who pointed out that students like to ork with computers because it was a **novelty** (10), added other easons. For instance a teacher stated that:

> "I think that they are attracted to the computer work because it is something new, but the doubts that I put to myself are: when the machine will no longer be something new, they may become de-motivated. Now they are extremely motivated and they like to touch, to see, it is like a game for them. And there is another aspect at the work level that I would like to emphasise, that is: both teachers and students are not under pressure to reach a level of knowledge, so they are more motivated to learn. As a result of this, the kind of relationship that is established between teachers and students is completely different, there exists friendship and they have a determination to expose their doubts, so we can say that we work on equal terms, students and teachers, and I think that is excellent".

This teacher focused on several aspects: the student' s active role , the teacher/student relationship, and the fact that, as there is no pressure to accomplish a set of content, teacher and student feel more motivated to learn. The word, or the sense, of "motivation" appeared several times in the teachers' answers, but in two different aspects: related with students' engagement in projects, or because computer work is like a game or merely a new thing.

> "Students like it because it works, and it is a technology for which they are motivated, since it is from their epoch".

> "... Children everywhere see computers, and they are fascinated; for them it is like a game and so very motivating ".

However other teachers relate the motivation to the kind f activities that students are developing or to deeper feelngs. A Visual Education teacher refers to this:

> "... Some students who have a certain amount of difficulty in translating on to paper some ideas they have, they come to the computer and accomplish their tasks easily and with enthusiasm. Some of them are quick to learn the technical aspect and others grasp it in an inhibited way because they are children with different characteristics, but I think that all pupils achieved something positive. Then they like it because they feel able to do something, they have success".

> "I see the computer as one more resource in my school and so, it enriched it, and as well its dynamic became a little different, because this kind of work fosters passionate arguments among students, and engages them since they are motivated".

A primary school teacher also approached the motivation .ssue, focusing on the results that pupils have and the power on :he computer: " I think they feel the work with computer as a :hallenge, and for them it is a new thing as well. They become engaged because they have right away the answers to their ques-:ions, experiencing a sense of victory through the outcomes which :hey achieve".

Seven teachers expressed this student feeling of success :elated to their computer outcomes, and another seven answers expressed the importance of students developing their own ideas. ;o the computer appears, in the opinion of some teachers as an pportunity for students to think and to do things that are ıeaningful to them, as the following statement of a teacher ;hows:

"I mainly think that this work may have interested them more towards school work, both in classroom and in club activities. Related with the projects which they do in the club, I think that they like to do things with a beginning, middle and end. To go to the computer and to do little things without a sequence, or a purpose, they also become bored. So they can do something that they can show to the other people at the school. Usually the school did not promote these kinds of things, before".

The social aspects are pointed out by three teachers, as a mathematics teacher said: "... To work with computers is considered a high status noble task only reserved for some people. The students feel proud of doing work that is considered important", and a primary school teacher also stated: "For these students all of them proceeding from a low social status, this is a promotion. Usually they see computers behind the shop windows, now they have them".

Another aspect already referred to is the power that students feel when they are working with the computer and that is well demonstrated by this opinion:

"... The work with computer results from the student-machine interaction, the student being like the teacher of the computer. The computer confines himself to execute the orders that are given by the student. In the work with computers, the student feels great autonomy, because it is him that runs the operations. When something is wrong, it is not seen as a failure, but as a challenge, and he asks himself- What is it necessary to change in order to have a perfect result?".

Most of these teachers had worked out of classroom, and their opinions were based on their concrete experiences in the computer club which they were developing through this school ear. The fact that they had observed so much enthusiasm and ersistence towards the work with computers, had some of them to xpress the desire to introduce computers within classroom in the ollowing year, as this teacher who said: "the computer is an xcellent auxiliary to learning several curricular subjects, so he computer should also be in the classroom, since it is inside he classroom that most of the learning take place."

.7. TEACHERS' VIEWS ABOUT THE ASPECTS WHICH COULD BE CHANGED AT CHOOLS BY THE USE OF COMPUTERS.

One of the aspects approached in the interview (annex F), as the main aspects to be changed in schools by the introduction f the computer in the work with students. Table D1 summarises eachers' responses to this question.

able D1: Teachers' responses to the question: In your opinion hat are the main aspects that may be changed at school with the ntroduction of computers in Education.

eachers' responses	Frequencies (out of 19)
chool aspects	
omputer as a new school resource	4
timulate projects in the school	4
romote global and interdisciplinary activities	4
Iodification of the school organisation	3
Curricular aspects	
Need to change the curriculum	3
Changes in classroom management	3
Changes in student assessment	2
Teachers' aspects	
Greater contact and work among teachers	2
Awareness of some pedagogical issues	1
New role of the teacher since she becomes support, a guide, a resource	1

All the teachers considered that computers change something in school, referring to positive aspects, with the exception of one teachers who said: "The computer can be dangerous, if it is used only to put done things there, and not to go forward". Most of the teachers pointed out several aspects together. The greater incidence was in the students aspects, which were already approached in the previous section 5.5.2. Changes in classroom ork were one of the aspects more focused on, as for instance hese two teachers who said:

> "The class can no longer be given by the teacher for all students. They must get used to work in an independent way, they must begin to plan out their own work, to organise and to discuss it with their school fellows... The teacher will be a support, a guide, a resource".

> "Mainly, we have to change the kind of activities within the classroom,... It is necessary to take out the tutorial lessons to work with the computer, because students have to do, and only not to listen. Fundamentally the activities must be built in a global way and fostering independent work, since this kind of work allow the student the use of computer as a tool".

The interdisciplinary activities were usually related by teachers to extracurricular activities and the development of projects, involving teachers of several areas:

> "... the computer can be used for interdisciplinary activities, which is very good since it provides greater contact among the teachers, and an awareness of some pedagogical issues".

> "I think that projects are important and this year we had a short experience which showed that it is possible to involve several teachers and students in a common project.

> "Concerning the school projects as that one of the awareness to the traffic problems, some teachers were engaged in little tasks, so it was possible to do some interdisciplinary activities".

To stimulate colleagues in the development of other activities, rather than just to "give lessons", through computer activities, was one of the aspects mentioned more by the teachers, some of them relating it to the fact that the computer might e a resource for both students and teachers, contributing in ome cases to a certain change in the life of the school.

"I see the computer as one more resource in my school and so, it enriched it, as well as its dynamic became a little different, because the kind of work fostered passionate arguments among students, and engaged them since they were motivated".

"I think that this work might increase their interest in school work, both in classroom and in club activities. Related with the projects which they developed in the club, I think that they liked to do things with a beginning, middle and end. To go to the computer and to do little things without a sequence, or a purpose, they also become bored. So they can do something that they can show to the other people at the school. Usually the school did not promote this kind of things, before".

"... I have in mind an enlarged project that involves all the school, therefore I have not proposed to work only in my subject area and to stop there.... I persist in saying that I am very inexperienced in working with the computer in the classroom, and later on I can even to reach the conclusion, that it was a way to be followed. But by this time, I have the experience of this past year which I have liked very much to participate in the project work that several teachers have done and for me it was really important. For that reason, I think that with combining the classroom computer activities involving other teachers at the same time is very important work. That is my opinion, which may be changed the end of the next year".

The contribution of the computer in curricular development aspects was one of the teachers' concerns expressed when they answered this second question. The need to change the curricula, student evaluation of computers in schools, and classroom management were issues to which teachers gave some importance.

"Well, now the computer is at school, not for everybody, but only for a part of it. When everybody is motivated to use computers, I think that the school will to change in terms of classroom organisation, and of curriculum development. And, then I think that students will work in terms of developing their reasoning, since there are several programs that foster reasoning".

"The school work management is completely different. With computers they stop being selfish and they get together in order to help each other. As this is a new thing they don't feel bad showing their ignorance about. The evaluation is also easier, now. When I have some doubts about what they are learning I ask them to go to the computer and I can understand what kind of progress they are making".

"...I already feel the need to change the programs and to articulate them with the secondary level. It is not possible to continue teaching as we do now, to prepare the students for the secondary level, to give them the knowledge they need to go on, and at the same time to work with computers, because we spend more time doing so.

"I think that the introduction of computers in the school may be a big revolution, when everybody is ready to work with them, and the way we teach now will be a caricature of the new ways of teaching".

In summary, when teachers were asked about changes in schools by means of the use of computers, they approached a diverse set of aspects, showing that they consider computers as powerful pedagogical tools for the changes they mentioned. The fact that the teachers, at the end of one year of working with computers, had shown that they viewed computers with potentialities to modify certain aspects in school, also showed that perhaps these teachers were already desiring that something could change the way that schools work in both students and teachers aspects; to make things better in such a way that could engage students and teachers in the life of the school.

.8. GLOBAL DISCUSSION

This chapter was concerned with the teachers' attitudes owards the use of computers in schools, at the beginning and uring the development of the training programme.

Since these teachers were volunteers in the MINERVA project, heir positive expectations at the beginning of the programme, eemed to me to be normal. However, at the end of this school year, teachers seemed to be more motivated to use computers in order to change things that they thought were not running very well, both in the dynamic of the school and in the students' learning, than at the beginning of the training programme. Initially most of them believed that computers could be useful for them as professionals and as individuals; later they focused on specific aspects, probably related to the experiences they had. Squires and Coward (1980) also said that in general teachers are unaware of applications of the computers in education as well as of the implied changes in the methods of teaching. Cox, Rhodes, and Hall (1988), found that "the majority of teachers believed that computers were used best to support rather than change current classroom practice" (p. 4).

During the development of the programme, and the practical work with their students, in formal and informal conversations, these teachers were approaching a lot of aspects: benefits for students, curricular innovation, changes in the life of the school, and personal gains concerning their pedagogical practice (these are analysed in detail in chapter 7). As they were unaware, before their attendance on the programme, of how to work ith computers and what kinds of concrete activities could ossible be developed in schools, the experiences they had during he training sessions was perhaps the most important reference or them, and had influenced the kind of activities they had mplemented with their students. This aspect is mentioned for nstance by Noss, Hoyles, and Sutherland (1990), who found that eachers involved in a course for the use of computers, used the ajor applications approached during the training sessions. It is noted by UNESCO (1989) in the Bulletin of the International Bureau of Education, that there are several applications of computers in education and different opinions about their educational use. Also changes in education caused by their use depends on the learning environment and the kind of activities proposed for the learners (e.g. Papert 1980, 1984, O'Shea 1983, Chandler 1984, Fey 1984, Beswick 1987, and Noss 1987). The way that teachers were introduced to this subject, which was a new subject for them, and the fact that the programme had working sessions that promoted reflection about pedagogical issues raised by teachers during concrete experiences, probably conditioned their views about the potentialities of computers in education. From a constructivist point of view, to know is to continually reconstruct our thinking about our own experiences, in such a way that "our actions can be restructured to a higher level of knowing" (Formam and Pufall 1988, p. 236).

One of the aspects most focused on by teachers was the students' involvement in their work with computers. Perhaps some of the aspects pointed out by teachers to justify students' motivation (for instance "students have the opportunity of developing their own ideas", "students feel success and pleasure with computer project outcomes", and it "is a challenge for students"), had been aspects that teachers themselves felt when they developed work during the training activities (Papert 1984, and Erault 1987). Concerning the benefits for students, teachers mentioned both cognitive and affective aspects, mainly related to the development of students' attitudes (for instance the development of creativity, reflective reasoning, and self-confidence, and the increase of cooperation among students). This could be interpretated in relation to the fact that the great majority of these teachers did not work inside the classroom approaching curricular subjects using computers, and perhaps because they were experienced teachers and they had already reached a professional stage where concerns other than those of learning contents are also important (e.g. Watts 1981, Pinner and Shuard 1985). Papert (1987) states that the use of computers in education reflects issues of educational philosophy. He distinguishes between two major approaches "child centred or development-centred" (to give children a greater sense of empowerment), and "curriculum centred" (to give instruction). And he adds that "the computer sharpens these existing cleavages in educational theory" (p. 5). In spite of what they said in interviews, after the first year of this study, there truly was no evidence that most of the teachers in this study had a development-centred attitude towards the use of computers in education. It was necessary to study them using computers within the classroom. This is the main subject of the following chapter.

CHAPTER 6

THE MATHEMATICS TEACHERS: RESULTS AND DISCUSSION

6.1. INTRODUCTION

In this chapter the work developed by the eight mathematics teachers during the second year of this study, as well as their views concerning the use of computers in mathematics education will be described, analysed, and discussed . The description of their histories from 1987, the year of the implementation of the teacher training programme, until the end of the school year of 1988, can be found in annex MT.

One of the purposes of the second year of this study was to observe the mathematics teachers at work with students, using computers in both curricular and extracurricular activities. The data gathered through the formal interviews, the informal conversations, transcripts of both classroom and computer club observation, and the analysis of the worksheets for classroom activities was additional information in order to delineate each teacher profile. The focus on these particular teachers provided an understanding of their evolution through the two years of the field work, and the identification of similarities and differences which were indicators of parameters leading to a further categorisation of the teachers. Furthermore this deeper analysis supplied an insight into the major issues of this research:

1) Teachers' views of their professional development (which will be dealt with chapter 7);

2) Teachers' views about computers in Education and in Mathemat-

cs education;

) Teachers' attitudes concerning teaching and learning.

This chapter has two main parts concerning the two last issues. All these themes will be summarised and discussed in the last chapter. In this chapter a preliminary section offers a brief description of teachers' activities in the second year.

6.2. TEACHERS' ACTIVITIES IN THE SECOND YEAR

All the mathematics teachers involved in this programme worked at preparatory level (with 10-12 years old students). All of them were experienced teachers with 12 to 28 years of experience (see annex MT).

During the school year 1988/89, the second year of this study, eight mathematics teachers were interviewed and observed in a more in-depth way, as is described in chapter four, on methodology. These teachers continued to work in connection with the node of the MINERVA Project at the Higher School of Education in Lisbon, attending seminars and workshops related to new software available and its pedagogical use, with other teachers also involved in the programme in the previous year. According to the teachers' interests, several groups were formed and were supported in the development of their projects. There were curricular groups in several subjects, and also a group of teachers especially concerned with interdisciplinary projects. Only one of the mathematics teachers was not involved in extracurricular activities with students but all the eight mathematics teachers belonged to the interdisciplinary group.

The main part of programme for this year aimed to provide pportunities for teachers to meet together in order to develop heir projects both in curricular and extracurricular contexts in heir schools.

Without interfering in the work that teachers were developng, data was gathered through classroom observation. The materils which they elaborated for supporting the work with students ere also analysed and this was complemented with the informaion obtained by interviews and informal conversations.

Six of the eight mathematics teachers involved chose to work n the mathematics curriculum, exploring both LOGO and the spredsheet SUPERCALC 3 (a commercial spreadsheet for the MS-DOS achines). Table M1 shows the mathematics content chosen to be pproached using a computer by these teachers in classroom activties. All the mathematics teachers went to the Node meetings, orking there on average two Thursdays each month, developing aterials, deepening their knowledge about LOGO and the spreadheet. This was even true for the two teachers who decided not to ork in the classroom with the computer. This team was coordinatd by the mathematics teacher who had been involved in this Node f the MINERVA Project for two years. As has already been said, his teacher undertook classroom work during the year of the evelopment of the training programme for this study. The role of his advisory teacher was to support the work of the teachers and ometimes to suggest some computer activities in order to deepen heir knowledge of the software used. Such support was organised o match their needs in developing the work with students. These ctivities were carried out for all the eight teachers involved.

here was one group who wanted more LOGO, and another which chose o focus more on the spreadsheet.

All the teachers had five MS-DOS computers in their class- ooms with two or three students working at each. The classes had 5 to 28 students, who were divided into two main groups: while ne group was working with the computers the other one was orking with other materials, such as worksheets and manipulative aterials. These two groups alternated work with and without the omputer.

\

able M1: Work developed by the mathematics teachers in 1988/89

eachers' ames*	School	Classroom	Club	Software	Mathematics content
aula	A	Yes	Yes	LOGO SC**	Rational numbers Geometry Proportions Sequences Graphs
atarina	A	Yes	Yes	LOGO SC**	Rational numbers Geometry Proportions Sequences Graphs
Ana	A	Yes	Yes	LOGO SC**	Rational numbers Geometry Proportions Sequences Graphs
Berta	B	Yes	Yes	LOGO (a) SC**	Proportions
Carla	C	Yes	NO	SC**	Proportions Sequences Graphs
Dina	C	No	Yes	LOGO (a)	Free projects with Geometry
Susana	D	No	Yes	LOGO (a)	Free activ.
Joana	E	Yes	Yes	LOGO	Rational numbers Geometry

* These names are fictitious
(a) In computer club
** SC means the commercial spreadsheet SuperCalc 3

.3. MATHEMATICS TEACHERS' VIEWS CONCERNING THE IMPORTANCE OF MPUTERS IN EDUCATION.

One of the objectives of the middle term interview (annex G) nd the last interview (annex H), was to examine the views of eachers, after a considerable time of working with students, elating to the use of computers in the mathematics learning rocess, and more generally to the role of computers in educa- ion. Teachers' views surrounded three aspects: the specific role f computers among other pedagogical tools; the influence of omputers in education and mathematics education; and teachers' pinions on how to use computers in schools.

.3.1 Has the Computer a Specific Role in school, or is it Another Resource?

All teachers considered that the computer in the school was a resource, with six adding that it was a resource with more educational potentialities, since "it is more enticing and it engages the students to think and to find their own mistakes as well" (Berta), or because "It is a living instrument, as the cinema of our epoch" (Ana).

Three teachers compared the computer with the overhead projector, establishing the difference like Dina who noted that:

> "...students need to touch and to do, not only to see as when they are seeing a teacher doing a lecture with the overhead projector" (2nd interview).

Two teachers related computers to changes in education; for example Catarina stated that "the computer implies a new methodlogy of work, ... all the structure of the classroom is differ-nt". Carla said that it was a facilitator of school change, but he added that "change must also be in peoples' heads".

Two teachers referred to the fact that computers were now pecific tools in schools, although this could change:

> "...In spite of their great importance in this moment, I am not sure if some years later they will have such impact as they are having now" (Paula, 2nd interview).

> "...When the overhead projector appeared and other instruments as well, they moved people on as now computers do. I don't know..., however it is more difficult to put computers away, since they have different potentialities. It will depend on what they are able to give to teachers. People are tired of working and not being rewarded for their engagement and effort. I believe that less and less people have less illusions" (Susana, 2nd interview).

Teachers' answers seem to reveal that they viewed computers as specific tools, focusing on changes and students' benefits. Some of these opinions indicate that teachers considered it important that computers could foster greater participation of students in the learning process. Also aspects related to changes in the classroom structure and in the school were mentioned. The two last statements show a certain doubt about the future, mainly the last one from Susana, the oldest teacher with twenty eight years as a teacher, which reveals that teachers were usually not rewarded for their efforts in implementing innovations in schools.

.3.2. **Teachers' views concerning the influence of computers on thematics Education**

Table M2 summarises the teachers opinions concerning the nfluence of the computer on education and specifically on athematics education. As the questions were open, providing free esponses, these were the aspects focused on by teachers.

able M2: Teachers' views concerning the influence of computers n students.

'eachers	Increase liking of Mathematics	Improve learning of Maths subjects	Develop cognitive aspects	Develop autonomy and discovery
;usana			yes	
)ina	yes	yes		
3erta	yes	yes	yes	yes
\na	yes			
?aula	yes	yes	yes	yes
:arla	yes		yes	
:atarina			yes	yes
Toana	yes		yes	yes

able M2 (cont.): Teachers' views concerning the influence of omputers on students.

eachers	Respect each students' pace	Increase self--confidence	Increase motivation towards school and learning
usana			yes
ina			yes
erta			yes
Ana		yes	yes
Paula			yes
Carla			yes
Catarina		yes	yes*
Joana	yes	yes	yes**

* This teacher refers to motivation as an important aspect, but due to the engagement of the students in projects meaningful to them.
** This teacher refers to motivation as an important aspect, since the situations are more problematic and students become involved when they investigate.

All teachers indicated student gains in several areas, both cognitive and affective: increase in motivation towards school and learning, and in liking of mathematics and development of cognitive skills. Concerning the cognitive ones, teachers focused on: intellectual training of students (3); better mathematics learning (3); development of students' reasoning and thinking (2); development of the students' creativity (1);

"...the intellectual training that this work provides for children. They learn to work with a computer program, the first time may be hard but when we change to other software they learn it faster, they don't need me anymore. I think that they become more independent" (Joana, 2nd interview).

"It is hard to say, but perhaps the fact of students building their own learning, their own knowledge. They are learning when they need" (Berta, 2nd interview).

"It is the development of creativity, and the possibility of seeing the children who have a lot of school failure begin to get some success and to become more and more selfconfident" (Catarina, 2nd interview).

The affective aspects most focused on were: increasing the tudents' motivation towards school work and classroom work (8); ncreasing the liking of mathematics (6); development of students' autonomy and more active participation in the learning process (4); and improvement of the self confidence of students (3).

"... I had a student who was very absent-minded, now he is working with another colleague, he seems another child so engaged is he, and he doesn't disturb the class anymore" (Ana, 2nd interview).

Dina, one of the teachers who was not working in the classroom, said:

"...The use of the computer in the classroom gives me still a certain confusion, because I have a syllabus to accomplish. However I recognise that children understand some geometrical concepts like the angle notion, polygons and the variable notion, better with LOGO" (Dina, 2nd interview).

Most of these statements show that these teachers viewed computers as pedagogical tools that could foster benefits for stunts. All the points focused on by these teachers were positive pects, which seems to reveal that they viewed computers in hools in a worthwhile perspective. They did not just talk out cognitive benefits or benefits mainly related to a better derstanding of the mathematics topics, but they focused on ther aspects concerning the process by which students develop heir motivation towards the school, or become themselves more articipative and independent in the learning process. Since hese aspects were considered as positive to students, it seems hat teachers were aware of these issues and thought that they ere important in the educative process.

5.3.3. Teachers' opinions on the use of computers in schools.

During the third interview (annex H), the first two ques- tions aimed to understand what teachers thought about the ideal way to work with computers in both classroom and club environ- ments, and so to get more data concerning the teachers' views about the use of computers in schools. The intention was also to discover teachers' opinions concerning the role of computers in these two situations, and if there was a great difference between them, in terms of the work which they would like to develop with students. The questions were approached in the following way: "Could you build the picture of both a computer club and a class- room situation, imagining you have the computers you need and don't have any kind of impediments".

This aspect is analysed in three parts:

(a) Computers in both classroom and computer club

(b) Computers within the classroom

(c) Computers in computer club

.3.3.1. Role of computers in both classroom and computer club

During the two years of work with computers with students, hese teachers had the opportunity to express their opinions oncerning the importance they gave to both locations of work: he classroom and the computer club. The first time that they ere directly asked about this issue was during the first inter-iew (annex F). The question was: "In your opinion which is more mportant in working with computers, curricular or extracurricu-ar activities?". Also through the analysis of their answers during the last interview (annex H) it was possible to understand their preferences, concerning these two locations of working with computers.

Table M3 show their preferences and summarises the reasons.

able M3: Teachers' preferences towards the areas of working ith students using computers.

eachers	Preference	Reasons (1st year)	Reasons (2nd year)
usana	Club	More st. have access to computers	Participation in School activities
ina	Club	"I feel more responsible...I have a syllabus to accomplish"	St. also learn Maths in club with LOGO
erta	Both	Extracurricular activities improve classroom work	Club support Classroom work
na	No choice (1st year) Classroom (2nd year)	"I have not sufficient experience yet to have an opinion"	Computers increase st. liking of Maths.
aula	Classoom (1st year) Both (2nd year)	Computers help st. to be engaged in Mathematics class	Both Proj. Work and learning Maths is import.
Carla	Classroom	Develop st. liking of Maths.	Foster problem solving
Catarina	Classroom	Develop st. autonomy and creativity	St. can go to the comput. when they need to accomplish work. (st autonomy)
Joana	Both	St. are always engaged in both spaces	Begin an investigation in class. go to the club and come back to the classroom

Most of these teachers revealed that they valued computers in curricular activities, even those who gave equal importance to both places. The three teachers that expressed the opinion that the work developed in these two places should be complementary, ve different reasons. Berta viewed the computer club as an .tension of the classroom in order to support the mathematics tivities:

"...I would like to have enough computers within the classroom, so that my students could have a minimum of technical computer knowledge, before approaching mathematics in order to provide the use of computers when it was useful. For instance, with LOGO, they need to know the turtle movements for its use in Geometry, but of course they would need to know more and more. ... The club is good as a support to the class-room activities".

Joana preferred to use both time available in the develop-ent projects and investigative activities by students without eing concerned with the separation into classroom/club:

"... I would go towards a freer project, that means, through several suggestions they could choose the problem solving situations, but where they already would have the possibility of choice of the kind of material to solve the situation ; it might be the computer or not. So they would choose the problem among those I would give them, they would choose the material and they would show the result of their work. ... Let us suppose that they want to investigate some mathematics theme, or to solve some problem, so starting from this point they would be able to use certain material, to do some research. I think that these projects could begin in the classroom and continue outside and come back to the classroom. My role would be to guide their work giving suggestions and resources.
...The club...this is the situation that I prefer, as is a more open situation, it provides a social contact and for very good relationships among students and among teacher and students. Students are there, not because they have to be or because they have to fulfil a schedule, but they are free to do things which they want to, and this fosters a very good relationship. It is possible to develop from any theme that can be chosen by them and the child working with each theme can choose his or her project. ... The ideal was to finish in the classroom. But what is the classroom? 50 minutes? This doesn't matter. I don't know if it is possible to finish it, but with this kind of work the wall that separates the classroom and the club is

already broken".

Paula (just in the second year) and Carla separated the work hat could be carried out in the two places saying that both were mportant to the development of the students.

Dina and Susana, who chose the club, also expressed differ-nt motives. Dina was more concerned with students' mathematics earning and Susana with the involvement of other teachers of the school in computer activities.

The concern with mathematics learning was mentioned by seven of these teachers. Two of the three teachers who put classroom work in first place (a fourth teacher also did this in the first year), referred to problem solving or investigative activities, as for instance Carla who stated:

> "If I could have enough computers within the classroom for everybody,...two or three students by each computer, I am thinking of activities with LOGO very close to mathematics topics, ...the spreadsheet is really important for problem solving.
> ... The club as a space for autonomous projects providing activities with team work, developing amusing projects without limited to mathematics topics" (3rd interview).

The analysis of these answers seems to reveal that these teachers considered both places important for students, giving a major role to computers in mathematics education. In particular the development of projects by students, with mathematics included or not (except Berta), seems to be important to these teachers.

3.3.2. Computers within the classroom

With respect to the kind of activities that teachers thought be worth developing in the classroom with computers, at the d of the school year 1988/89, these eight mathematics teachers id not show the same attitude. The greatest difference was con- rning problem solving versus sequenced activities with the upport of worksheets. Problem solving also had a different eaning, whether problem solving directly approached one topic for instance proportionality) or constituted broader situations nvolving more that one topic and providing investigative activi- ies.

The following table displays the aspects which they empha- ised in third interview (annex H).

able M4: Teachers' attitudes concerning the work to be developed ithin the mathematics classroom.

eachers	Sequenced activities	Problem solving	Investigative activities
usana	yes		
ina	yes		
erta		yes	
na	yes		
aula	yes		
arla		yes	
atarina		yes	yes
oana		yes	yes

Three teachers would prefer to have a lot of computers thin the classroom and develop more structured activities, with sequence and with the support of worksheets guiding the stunts' work, as for instance Dina and Ana:

> "I would like to set them work with a sequence...I have to structure the knowledge inside their heads" (Dina, 3rd interview).

> "I would want a larger number of computers and a big room. So it was possible not to have to work with half of the class with the computer and the other without as I did last year, since a teacher alone doesn't get management of all the work; it is very hard. Two students by each computer would be the ideal situation. To have the possibility of photocopying worksheets for all the students. I would work with LOGO for Geometry. I would begin with activities proposed by me and little by little I would extend student participation, because they are too young and at this age the teacher should direct in the beginning. But it is also important that they participate actively since they are creative people" (Ana, 3rd interview).

An opposite attitude is shown by Catarina's response:

> "...they will come to the computer and another group go to work with other material and I will go through several groups helping, guiding them. I think that it is important that students go to work with the computer when they feel that there is a need and not because the teacher says them to work with computer as a structured activity" (3rd interview).

In the group of four teachers who referred to problem solvng, two (Catarina and Joana) were also in favour of open rojects which should include investigative activities. Paula lso mentioned projects but in another perspective, as a complerent to the sequenced activities:

"I would like to have more time, you know the student schedule has few hours for Mathematics, to do Maths and to use the computer for students developing their own projects related to Mathematics" (3rd interview).

Also the aspect related to diversified activities within the lassroom would not be a choice for four teachers (Carla, Ana, ina and Susan) if they have a sufficient number of computers vailable:

"If I had computers for everybody, I would put all of them working with a computer. I don't like diversified activities, since those who are not at the computer become blank" (Carla, 3rd interview).

The answers to this question show different attitudes concerning the use of computers within the mathematics classroom. Probably these teachers were influenced by the work that they were developing during this last year. The need to introduce diversified activities was due to having only five computers in the classroom. This implies classroom organisation different from what teachers usually did, and a certain loss of control of all students' work. Considering the fact that most of these teachers probably used to centre the lessons on their explanations of content this increased their work as well as seeming to make them feel worried by not handling all students' activities. Another reason could be due to different conceptions of what a mathematics classroom should be as well as different objectives of mathematics for these students. If teachers were mainly concerned with the accomplishment of a syllabus as it was written in the curriculum and in the textbooks, this could be a factor which fluenced their opinions.

3.3.3. Computers in the computer club.

In the computer club all the teachers (except Berta) men-oned the development of projects by the students, but this did t mean the same thing for all of them.

The table M5 summarises the answers of these teachers to the terview (annex H, 2nd question)

able M5: Teachers' attitudes concerning the work to be developed n the computer club.

eachers	Short activities *	Project work *	Support classroom work
usana	yes		
)ina		yes	
ꞩerta			yes
ʌna	yes		
ʾaula		yes	
:arla		yes	
:atarina		yes	
ſoana		yes**	

: I call project work, even when teachers didn't mention this lesignation, when teachers emphasise that projects have an inte-grated idea, involving the interests of students and team work. ;hort activities are individual activities, such as drawing a ıouse or a boat, without relation to a project.

:* This teacher mentioned that projects should be developed in ›oth classroom and club without separating the work developed in :ach place.

Two teachers said that the hours of computer club should be dicated to students doing what they wanted to. Usually students ose to draw something with LOGO or with a drawing program (GEM INT). Susana also held the opinion that the computer club ould collaborate with school activities such as the celebration f some festivities, as she said: "the intention is to do inter-isciplinary, to involve more and more students and teachers,... tudents are easily engaged, the great problem is to engage the eachers." In these cases students were asked to do something on he computer to answer some request of some teacher. Other teach-rs valued the projects which started from the students, and hich could be developed in group work, as Paula said:

> "I have to admit that to do work in the club is worth-while, it is necessary to do Work Projects. ... I'm thinking challenging the students with a theme and studying it with them, since I have understood that when they are doing only unrelated activities, they soon become bored.... The theme should interest the students..."

Berta, for example, defended the idea that the computer club should be a support to the classroom mathematics work, providing :he students with basic technical knowledge. According to Joana :he computer club and classroom should be linked in order that students could develop their projects using both school loca-:ions; the projects could begin and finish in either the loca-:ion.

;.3.4. Discussion

The analysis of the opinions expressed seems to show that hese teachers viewed the computer as a pedagogical tool that ould be used to approach mathematics topics as well as to in- olve students in projects related or not related to mathematics, ut they have different attitudes concerning its use in schools. ince they had begun working with computers at the same time, had orked together over two years, exchanged their experiences, ttended the same teachers training programme, perhaps the dif- erences which appeared could be due to different views of the eaching and learning process, the role of teachers and students n this process, and their beliefs about mathematics and educa- ional objectives. These observations correspond to those of OECD eport (1986), and CERI document (1986).

Relating these results to the initial opinions of all teach- ers in this study (chapter 5), just before the teacher training programme, differences over time with respect to the positive role of computers in education can be seen. At that time teachers were very hopeful that computers could be a change factor in education, innovating the teaching learning process. The aspects that teachers focused on at that time were more vague than after concrete work with students. For instance, concerning the bene- fits to students, they initially only wrote about "to increase student motivation towards school", "to foster students capaci- ties" and "to decrease school failure by the improvement of students' learning". Some statements (9 out of 27) showed that teachers set themselves apart from the process of students' improvement, giving this role to the computers, as exemplified by this teacher who wrote: "Perhaps the computer can solve some arning problems that even we don't know the solution to" (cited chapter 5). It seems that at the end of the programme, and ter these two years of working with students using computers, achers were aware that their implication in the process was undamental.

Later on, during the development of the teacher training rogramme, and when teachers had already implemented some activi-ies with students (chapter 5), it was possible to see that eachers referred to aspects such as "team work with cooperation mong students" "student autonomy", and "investigative skills", motivation towards the school work", with the largest number of esponses to "the development of creativity" (15). At that time he emphasis on this skill was probably due to the fact that hese teachers didn't work within the classroom during the first ear, but the in club, working in a group with their colleagues, mplementing interdisciplinary projects with students, free of he obligation of contents of disciplines. Also the motivation ssue approached by teachers since the beginning, showed that eachers would like to see their students more engaged in school ctivities, and this could happen when students were working with omputers. This could explain that most of the mathematics teach-rs (6 out of 8) chose to experiment with the introduction of omputers within classroom, expressing "the increased liking of athematics", and "the increase in motivation towards school earning", as one of the greatest benefits to students (see table 2).

Another aspect that seems to be of underlying importance, as the aspects which were pointed out by four teachers who introduced computers in mathematics curriculum. Problem solving (4 teachers) and investigative activities (2 teachers) were cited as activities which could be fostered by the use of computers. As mathematics education was in those days giving emphasis to these kinds of students' activities, teachers found in computers a good pedagogical tool to approach problem solving and investigative work. Other four teachers showed another attitude, mentioning structured and sequential activities to approach mathematics topics. This difference of opinions concerning the use of computers in mathematics teaching may reflect differences in educational objectives: child centred or development centred or curriculum centred, (Papert, 1987).

The positive expectations that teachers brought to this project (they were all volunteers) probably had some influence on the positive role they gave to computers in schools. Never did any of these teachers refer to any inconvenience of the use of computers in education. However some teachers showed a critical sense, saying that it was necessary to reflect on when it was worthwhile to use computers to approach mathematics curricula, and when it was not. This fact revealed some maturity and understanding of the educational potentialities of computers, mainly in mathematics education.

The fact that teachers were not applying an innovation made by others, but they were partners in the process of the introduction of computers in education, could be a factor in influencing their positive views. This issue is addressed in literature by such authors as for instance, Fullan (1982), Rudduck (1991), and the authors of the Israeli "Project Comptown", that show the portance of teacher involvement in the implementation of an novation in schools.

Another reason may be that the software used (LOGO, and tilitarian tools) and the fact that they had freedom to choose he activities to be developed with students could be an explanaion for this unanimity concerning the positive attitude that all hese teachers showed towards computers. "Content free tools" Chandler 1984) can provide stimulating way of learning as for nstance databases and spreadsheets which can develop some stuents skills (Parker 1986; Chandler 1984; and MacDonal 1988).

;.4. TEACHERS' ATTITUDES TOWARDS THE STUDENTS' LEARNING PROCESS ND CLASSROOM PRACTICES.

One of the goals of the teacher training programme was to nfluence teachers in approaching the teaching/learning process n a more active and participative way by students, motivating hem to an attitude of investigation and inquiry. As it was said n chapter 1, Portuguese teachers usually approach Mathematics in very formal and didactic way. The participation of students in mathematics class is mainly to solve routine exercises rather han problem solving or developing investigation activities.

In the last section I tried to analyse and discuss the athematics teachers' views through what they were saying, which howed personal positions towards the use of computers in educaion and in particular in Mathematics education. It was important o know their views and their intentions to act, but it was also ecessary to observe their actions.

In this section I will analyse their practices together with hat they were expressing during formal interviews and informal onversations. These informal conversations mainly occurred after y observations in both classroom and club environments, as well s during working sessions. The annex MT describes in a detailed ay personal histories of these eight teachers since they began o be involved in MINERVA project, the school year 1987/1988, ntil the end of the school year of 1988/89.

.4.1. Practices of teachers who used computers in Mathematics lassroom.

As has already been reported, all the eight teachers met ogether on average two times a week to prepare the work to be eveloped in classrooms with students; however they chose different software as well as different mathematical contents (see table M1) to approach this. The teachers developed some worksheets to support the students' activities with both LOGO and the spreadsheet. Some examples can be found in annexes R1, R2, R3, and R4 (LOGO, Rational numbers), P1, P2, and P3 (LOGO, Geometry: angles, length of a segment, polygons), S1, S2, S3, and S4 (Spreadsheet, proportionality, sequences and graphs).

The analysis of the worksheets shows that R1, R2, and R3 are more structured and closed than R4 which challenges the students to solve a problem. Also the worksheets to approach Geometry are very structured, mainly P1 and P2. All the spreadsheet worksheets are more open providing opportunity for problem solving situations (for instance S3), criticising the results (for instance

), or investigating a rule (for instance S4).

Also the way that teachers who had chosen the same kind of ftware worked with students, was sometimes different (see nex MT, where each teacher is described in detail). For in- ance the worksheets to introduce Geometry were developed in a oup, but Catarina did not use them with students as she thought at they were too structured, preferring to suggest to students at they should discover the procedures for obtaining the poly- ns, and asking students to draw more complex pictures based on lygons.

> "I had some doubt as to whether I should give them polygons formally or if I should allow them to discov- ery the procedures. I chose the latter situation. I'm going to experiment this way, let's see if they learn something" (Catarina, 24/1/89).

Table M6 summarises the kind of activities which were de- 'eloped in a classroom context, by six teachers, since Dina and ;usana did not choose to work with their students within the ıathematics classroom using computers.

Four teachers promoted regular problem solving activities ısing computers; however Carla and Berta during the classes ʼithout computers gave lessons to explain the topics approached ʼith computers, maintaining their sequence which was "disturbed" .n these teachers' opinions through the use of computers.

> "I need to systematise the topics, the computer breaks the topic hierarchy and for some students this is confusing, they need the topics set in order" (Carla, 2nd interview)

"For me it is very important to have lessons to provide a systematisation of the topics, for instance with proportionality, after work with the spreadsheet" (Carla, third interview).

The need to alternate lessons with computers with lessons thout was also expressed by Ana and Paula with sentences such "provide the consolidation of subjects", or "during this time try to organise their knowledge" (Paula, 2nd interview). These o teachers implemented the most structured worksheets to aproach Geometry, but even so they felt that computers, in some ay could imply some confusion in students' understanding of athematics topics because it broke the usual hierarchy.

'able M6: Practice of the teachers who use computers in the [athematics Classroom.

'eachers	Structured activities	Problem solving	Students discussion	Student autonomy
·erta		yes	yes	
.na	yes		yes	
'aula	yes	few *	yes	
:arla		yes	yes	
:atarina		yes	yes	yes
'oana		yes	yes	yes

' Paula promoted a few problem solving situation with the Spread- ·heet.

[ote: During the observation it became clear that problem solving .ad different meanings.

All these six teachers worked with students in groups proting discussion among them during the classes. They went to e groups, asking questions and waiting for their answers, sking if all children agreed with some students' answer.

Joana and Catarina did not seem worried with the fact that everal groups were in different phases of attainment of their asks, which was a concern for the other four teachers, who menioned this aspect several times, as for instance Ana:

> "It is hard to manage all the groups doing different things, there are always some students who finish quickly, I needed more time for this kind of work. Also the diversified activities, with students doing different things is very tiring." (21/2/89).

All the teachers who introduced computers within the classoom decided to develop diversified activities. After this experience, Carla and Ana expressed the desire not to repeat this style of work organisation. Carla said that:

> "If I had enough computers for everybody, I would put all of them working with computer. I don't like diversified activities since those who are not on a computer become bored, if they do not have a very stimulating activity out of computer".

It seems that teachers who refused to develop different activities at the same time, within the classroom, lost control of students' learning (Carla), and it was difficulty "to manage all the work" (Ana).

.4.2. The influence of the use of computers on the Mathematics rriculum.

The following table provides information about teachers' iews concerning the influence of using computers in mathematics urriculum and how they affected the way they usually worked with heir students.

able M7: Teachers' opinions concerning the influence of the use f computers on the Mathematics curriculum and the way they each.

eachers	Alter the sequence of Maths content	Promote group work	More student participation
erta			yes
Ana		yes	
Paula	yes	yes	
Carla	yes		yes
Catarina	yes		yes
Joana			yes

ble M7 (cont.): Teachers' opinions concerning the influence of e use of computers on the Mathematics curriculum and the way ey teach.

achers	Classroom organisation	More noise/ enthusiasm	Think of new strategies or different worksheets
rta			yes
a	yes		
ula		yes	yes
rla			yes
tarina		yes	
ana	yes		

te: Results are shown only for teachers who developed work thin the classroom.

To foster the active participation of students in the devel-pment of classroom work was the aspect most focused on by these eachers, followed by the need to alter the sequence of mathemat-cs content and to think of new strategies for classroom work. owever Paula and Carla viewed the alteration of content ierarchy as an aspect that they did not appreciate very much nd that could bring some confusion to students.

The implementation of problem solving activities was focused n for instance by Joana:

> "I have dedicated more attention to problem solving situations. Usually I use to modify something every year, because I like to change, but now the changes are deeper. The team work has raised for me a lot of issues, such as the organisation of groups, and problem solving as well. I need to reflect what are my objectives when I set them a certain situation to solve." (2nd interview).

Most of the effects of introducing computers in mathematics tivities were considered positive, except the alteration of the quence of contents (Carla and Paula), and classroom organisa-on, in particular the aspect relating to the diversified activ-ies. Even the increase of noise by students, was viewed as sitive as Paula stated: "The classes are noisier now, but it is noise due to the enthusiasm of pupils and related to their work nd their discoveries" (2nd interview).

.4.3. Practices of teachers in the computer club

The analysis of data concerning the work developed by these eachers in the computer club situation is summarised in table 8.

'able M8: Practice of the teachers who used computers in the :omputer Club during 1988/89 (a).

'eachers	Unrelated activities	School activ. (colabor.)	Project work	Mathematics activities
;usana	yes	yes		yes
)ina			yes	yes
;erta				yes
ına		yes		
'aula		yes	(b)	
:atarina			yes	
Гoana			yes	

'a) Carla did not develop any work in computer club during this ear.
'b) At the end of the school year, this teacher expressed the ill to develop project work in the following year, and in fact he dedicated most of her time to doing it.

Dina who did not use computers within the classroom chose to edicate a considerable time in the club working so as to ap-roach mathematics topics of the curriculum, as she recognised hat students understood geometrical concepts better with LOGO. he other teacher who took the same choice of not using computers n the classroom, Susana, only spent a little time with Mathemat-cs preferring to develop some activities with LOGO, such as rawing a car, a boat or a house, chosen by pupils. Dina gave a ot of importance to project work and she involved the students n the global project "The interplanetary trip", which was a roject of some teachers involved in the node of the MINERVA roject in the Higher School of Education of Lisbon, and where others teachers were involved. Berta just used the computer club to prepare classroom activities, providing students with techni-cal knowledge. She maintained this attitude even with LOGO, as she was concerned to approach mathematics topics in the mathemat-ics classroom. The problem solving situations that could be provided by the simple use of LOGO, were not valued by this teacher.

Teachers who did put an emphasis on separation between mathematics and the work developed in the club, usually used other software, such as word processing and drawing programs. Joana's pupils were involved in a journal, a project that started from the computer club of their school, and they were also col-laborating in the "interplanetary trip".

.5 CATEGORISING THE MATHEMATICS TEACHERS

Through the analysis of data I tried to categorise the athematics teachers involved in this research, with respect to heir attitudes towards the use of computers in both curricular nd extracurricular activities as well as the way they viewed omputers in the student learning of mathematics. As teacher evelopment is a personal dynamic process and a continuum (Fullan 982, Watts 1981, Rogers 1992), this categorisation just attempts o define broad categories of the eight mathematics teachers uring the two years since the teacher training programme began nd **at that moment** when the field work for this study was over.

As was stated in chapter two, past experience of teachers s an important aspect of teachers professional development Calderhead 1987, Erault 1977 and Pope 1980), in particular in he way that teachers are affected by in-service training pro- rammes.

Also perhaps the way that teachers used computers and inte- jrated them in mathematics classroom was influenced by the way :hey interpreted their role as mathematics educators, as well as :heir educational philosophy (Papert, 1987).

The detailed analysis of the data of these eight teachers luring the two years show differences among them, as well some similarities in their attitudes towards computers in schools, lamely in mathematics education, and in the "evolution" of their ıttitudes. The method they followed, that means the kind of ıctivities they chose to develop with students with computers, luring these two years was also not the same for all the teach- ers.

All of them had twelve or more years of experience as hematics teachers when they were involved in the MINERVA oject.

They were volunteers in the project and they had never used mputers in their professional lives. According to ideas of tts, and Pinner and Shuard ideas concerning teacher profession- development, the mathematics teachers in this study had al- ady overcome the "survival" stage (Watts 1981) or the "initia- on" stages (Pinner and Shuard 1985). Probably all of them had lready reached the stage of mastery as it is characterised by atts:

> "Routines of management and response are automatic, and the teacher is talking about burn-out or boredom... The class is 'under control', parents are quiet, children do learn to read, conjugate French verbs, and pass their math achievements. Most classroom situations present no surprises, what's the problem? Just that" (p.33).

This accords with most of the answers of the teachers just t the beginning of the teacher training programme (see chapter ive). Thirteen teachers wrote that they were expecting to im- rove and to innovate in their teaching and six responses re- erred the need to "not stop", or "not crystallise".

One of the aspects that can differentiate between these eachers is their choice of working or not working within the lassroom. I decided to distinguish them by this aspect, since he two teachers who took this decision were worried that comput- rs would be a factor which, in some way, would lead to disturb- ng the accomplishment of the Mathematical content of the curricm, in the way they usually did it (Dina and Susana).

Concerning the other six teachers, I could see two groups cerning the work they were developing within the classroom: achers who emphasised the hierarchy of mathematics content and o showed a need to control students' learning, and those who emed to be more at ease without being concerned about these as- cts. These latter teachers were not worried by the fact that e different groups were working at different paces, and doing fferent tasks; they also provided greater student autonomy in e learning process. Each of these groups will be described in re detail below.

Category A: Teachers who did not introduce computer activities ithin the mathematics classrooms

Two teachers are in this category: Dina and Susana. However ne reasons they offered for not using computers in mathematics lassrooms were different. Also the work they developed with omputers in the club with computers was different. Both these eachers were sticking closely to the content of the curriculum. or them, the main teacher role was to accomplish the syllabus. o mathematics education became a set of hierarchical topics, nd its goal consisted of mathematical knowledge acquisition by ne students. As Beswick notes there are teachers who "assign igh priority to 'covering the syllabus' in terms of its subject ontent, and feel they are working under considerable pressures o 'get them through the exam'"(p. 37).

Dina was afraid to waste time using computers, in spite of he fact that she realised, as she showed when she developed a onversation about the activities that students developed in the lub, that they understood and learnt Geometry with LOGO. The ressure of the Mathematics curricula in terms of accomplishing ll the topics in a sequenced order was expressed by this eacher, who felt a professional duty to finish all the topics, hen she said:

> "...I recognise that children understand the geometrical concepts much better with LOGO like for instance the notion of angle, polygons and the notion of variable. They get the meaning of these notions. But in the mathematics classroom I have no time available to work with computers, students need to go to the next school year knowing the contents of this year" (second interview).

Dina adopted a teacher centred attitude within the classroom and considered that the time spent in the classroom was for presenting subject matter; students never worked in groups.

This teacher developed open projects with students in the computer club where students were at their ease working in groups, promoting students' discussion; however as she said, inside the classroom students were in ranks listening to her explanations of mathematics. At the end of the second year of this study, she showed the will to introduce computers in the following school year, which actually happened. The computer club was for "other things" (her words), which included open projects and group work. As she said:

> "At the moment I think that I am not able to bring the computer inside the classroom, because I have a syllabus , some topics to fulfil, and it is important to accomplish it. So if the computer comes to disturb in

some way this accomplishment, I don't agree. I feel the necessity of working one more year in the computer club, and then perhaps with more experience I can begin with curricular activities, but I have my doubts, since each person has her way of working, her technique; we may change something but the fundamental remains" (1st interview).

"...I worked by projects in the club and the things they learnt came because of the need they had to accomplish them,... within the class there must to be a sequence of activities,... I have to structure the knowledge inside the student's head" (2nd interview).

These last statements reveal how Dina separated the location f working with computers. She showed an awareness of students' engagement in the activities, as well as a student centred attitude during the development of the students' projects, providing discussion among students.

Dina also showed on interest in seeing the results of her colleagues, who introduced computers in mathematics curricular activities, and then in deciding if it was worthwhile to try similar work. At the end of the second school year she already showed the will to work within the classroom in the following year, which has since happened.

Susana, the other teacher who did not work within the classoom with computers, referred to the lack of appropriate software for providing better student knowledge acquisition. She stated that she would like to have a sufficient number of computers, software and worksheets to approach the mathematics topics which would help to orient students' work.

"...If we had a lot of appropriate software for the different mathematical topics students might go to the computer removing their doubts,... to reinforce, to practice. In other ways, I am not able to see if students really accomplish work with the computer, since it is very difficult for a teacher with 30 students to manage all the work" (27/2/1989).

She had experimented, in the computer club, a tutorial oftware program for solving numerical expressions, which she got y herself, and she expressed her disappointment after this xperience. The following statement show her ideas very well:

"...I feel myself unable to see if all the students really accomplished their tasks with computers, since it is very hard for a teacher with thirty pupils to handle all this work. What I could see with this experience, was the students running to the computer to check if the results of the exercises which they had solved with paper and pencil were well done, and I lost control. At a certain moment I noticed that they did not need me anymore. There was a great confusion and I lost control" (first interview).

In the computer club Susana developed some short and unrelated activities with students, who worked in groups of two. She showed the will, in the future, to collaborate in the celebration of some festivities such as "Tree Day", where students could compete with a picture, a design or a poem. To carry out this kind of work she intended to ask her colleagues in other subjects to collaborate, in correcting students' work. Her intention was to involve more teachers. As she said "I need the collaboration of the other teachers, because students are easily engaged".

ategory B: Teachers who introduced computers within mathematics lassrooms.

Four teachers are in this category: Ana, Carla, Paula and erta. These teachers developed systematic work with computers nside the classroom, working with students in curricular activiies. Some of the activities were very structured, but they were ware of the importance of discovery based activities. For these eachers mathematics education was a set of skills and capacities nd not only a collection of mathematical content. The developent in students of some skills such as logical reasoning, roblem solving, were important aspects to take into consideraion in student learning of mathematics.

This is explicated in the following statements during the second interview:

> "We are trying to work in curricular activities, with LOGO in Geometry, and indeed I think that this provide a development of students' reasoning. They have to think how to do things, they have to think about things" (Paula).

> "Teaching proportionality with the spreadsheet, it is really important as students do problem solving, but it requires much teacher thinking and reflection as the programme is very rigid and not interrelated" (Carla).

> "...it fosters the pleasure and a liking for learning mathematics. They don't become bored, as they can find their mistakes, which is not possible in other way. It also develops their concentration and reasoning, looking for problem solving solutions and for several ways of solving a problem. They can criticise the solution and this is very important indeed" (Berta).

> "Computers make the students think and this is a fundamental aspect. I have been thinking that they need time to reflect, to reason, without wasting time doing calculations" (Paula).

They recognised that students learnt better having an active le in the learning process, if they had time available to ink, to try out, discussing with their peers.

These teachers considered that it was for the teacher's ompetence to decide on all students' activities in the learning rocess, and they reclaimed time to systematise the students' earning. Also the hierarchy of the contents seemed to have great mportance, alternating lessons with computers and lessons without.

> "For me it is very important to have lessons without the computer to provide a systematisation of the topics, for instance with proportionality, after work with the spreadsheet" (Carla, 2nd interview).

Ana and Paula viewed the computer club as a pedagogical space, where students could develop individual projects, and more enjoyable work, developing other kind of skills as for instance creativity. This aspect was pointed out by Ana:

> "...The club should have also a teacher of fine arts working together with the mathematics teachers, as we don't have the creativity which students need. They like to do pretty things and these teachers could guide them" (3rd interview).

Paula also separated both club and classroom work recognising that it was possible to learn by means of work projects, but out of the classroom:

> "Children like us like to play, that means we should allow them to do their own projects...I have to admit that in the club it is necessary to do work projects" (3rd interview).

Carla considered that the club could be a space for students ing research, but she also said that: "the club may also be a ace where students develop amusing projects without being stricted within the mathematical topics".

For Berta the computer club should be a space to prepare the assroom work, that meant a space where students could learn out the technical aspects of computers in order to extend the me in the mathematics classroom.

ategory C: Teachers who developed more free work in mathematics lassrooms

Two teachers were in this category: Catarina and Joana. For hem, students should have significant autonomy in the develop- ent of classroom activities, having an important role in their earning process. The teacher here was an organiser of student ctivities, a help and a resource for the students. These teach- rs introduced computers inside the classroom because they hought that it was a very good instrument to foster the kind of ctivities that they desired to implement in the classroom, fos- ering attitudes of discovery, inquiry, problem solving.

They promoted independent learning, open-ended work and rojects. For instance Joana was very enthusiastic about LOGO, as he said:

> "LOGO is a challenge for their brains. With LOGO there are always new things to learn, so they discover a new thing, they do it, and then another thing appears, and they want to try, and so on,...they are going to construct the things by themselves, and through the work they do, they learn. So what children learn is not established before" (1st interview).

Also Catarina stated that:

> "...I have understood that students must have more power in the development of the class work, and that we can trust in the student ability to go further" (29/5/89).

These teachers didn't give too much importance to the com- uter, considering that it could be a tool that students could hoose or not as was referred to by Catarina:

> "I think that is important that students go to work with the computer when they feel that there is a need and not because the teacher tells them to work with computer in a structured activity" (3rd interview).

Also Joana mentioned this aspect:

> "If I had students with whom I had worked last year with the computer, I would go towards a project more freely that means, through several suggestions they could choose the kind of problem solving situations, but where they already have the possibility of choosing the kind of material to solve the problem, it might be the computer or not....depends on the kind of research they had to develop" (3rd interview).

These teachers didn't view the computer club and the class- room as separated spaces in the school, as was reported by Joana:

> "...I think that these projects could begin in the classroom and continue outside and come back to the classroom. My role would be to guide their work giving suggestions and resources. In those cases in which students aren't able to do the project, I would help them in order to not let the project to die" (3rd interview).

These teachers showed they felt at ease handling the mathetics curriculum without being concerned with the sequence of e topics as well as just the knowledge acquisition by students. mputers did not seem to disturb the development of classroom rk even with diversified activities or the fact of students eing in different phases of attainment of their tasks.

.6 BERNSTEIN'S VIEW OF CURRICULA IN RELATION TO THE FINDINGS OF IS STUDY.

Bernstein's theory concerning curricula and pedagogy offers good framework to better understand the findings of this study oncerning the mathematics teachers in their ways of working with omputers with students.

Bernstein (1973), analyses formal educational knowledge defining two kinds of curricula: collection - strength of the boundary between contents, and integrated - reduced insulation between contents through the "subordination to some relational idea" (p. 93). He introduces the concept of classification that is the degree of boundary maintenance, and the concept of frame which is used to determine the pedagogical relationship between teacher and students in which knowledge is transmitted and received. The concept of frame which is directly linked to the process of transmission and acquisition of knowledge can shift from strong to weak forms according to the level of teacher control in this process. So classification and frame are two educational codes which are fundamental concepts in Bernstein's theory as they define the "degree of control teacher and pupil pose over the selection, organisation, pacing and timing of knowledge transmitted and received in the pedagogical relationip" (p. 89). According to Bernstein the structure of the mesge system is a function of the strength of classification and ames. Strong frames reduce the students' power over what, when d how they acquire knowledge and increases the power of the eacher. Teachers' power is reduced in a strong maintenance of ontents boundary as they cannot over-step the boundary between ontents.

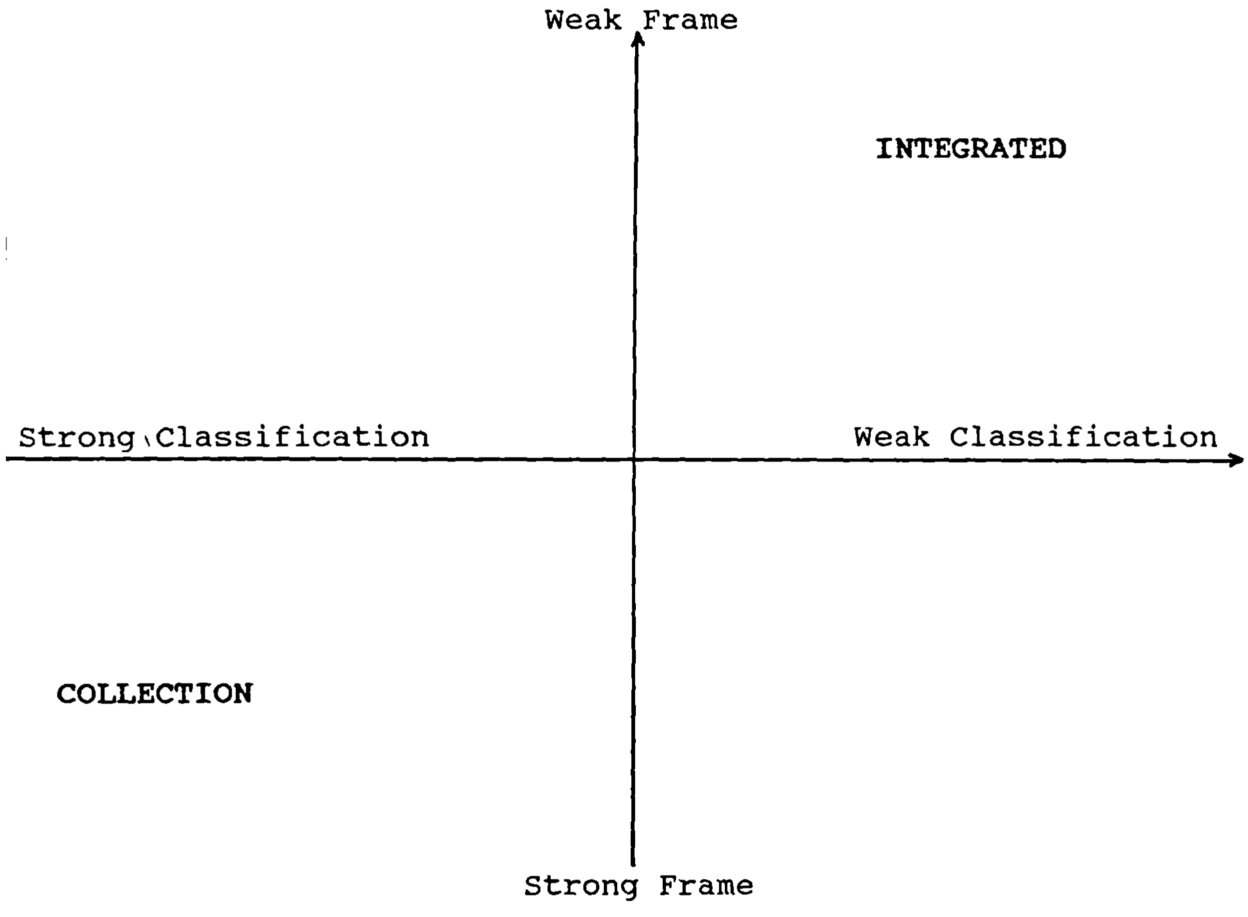
The collection type of curricula involves a hierarchical rganisation of knowledge and can be examined in various terms: ure or applied contents; everyday community knowledge, and ormal educational knowledge (confined to one subject or crossing ifferent subjects).

An integrated type of curricula can be "teacher based" or "teachers based". In the first case the teacher keeps the "various subjects distinct or insulated, or he can blur the boundaries between the different subjects" (p. 93). The second case involves relationships with other teachers, which are usually required to implement interdisciplinarity in schools.

Portuguese Mathematics curricula are usually organised with a strong boundary between contents, even the curricula of the preparatory level (10-12 years old students). Teachers have a syllabus to accomplish during a school year and they feel the obligation to do it, because students cannot go to the following year without having been "given all the subjects". If they fail to cover all the topics, teachers feel bad in front of their colleagues, as sometimes students change mathematics teacher every year. Another aspect of Portuguese school reality is the

rong frame, using Bernstein's designation in the teacher stu-
nt relationship in the learning process.

Considering these two variables: classification and frame d trying to represent them in two coordinated axes, we can have framework like that of the next diagram, where the horizontal is represents classification, from strong to weak, and the rtical axis represents frame also from strong to weak forms. ccording to this schema "Collection curricula" should be in hird quadrant and "Integrated curricula" in the first.



In a collection type of curriculum students are encouraged o work as isolated individuals, accepting a given selection of equenced subjects, according to a determinate pace, the same for ll, and with timing of the knowledge.

> "The stronger the classification and the framing, the more the educational relationship tend to be hierarchical and ritualised and the pupil seen as ignorant, with little status and few rights....Depending upon the strength of frames knowledge is transmitted in a context where the teacher has maximal control and surveillance, as in hierarchical secondary school relationships" (p. 98).

With a progressive weakening of the frame and classifica-ion, the various contents are subordinated to some theme which reduces the teacher' control in the learning process. In Bernstein's words: "there is a shift in the balance of power, in the pedagogical relationship between teacher and taught". (p. 101)

Relating the categorisation of the mathematics teachers of this study, developed in 6.5., to Bernstein's approach to curricula, and considering the schema of coordinated axis showed above, the three categories will be as follows:

Weak Frame

INTEGRATED

Cat C

Cat. B

Strong Classification

Weak Classification

Cat. A

COLLECTION

Strong Frame

Through the analysis of data it seems that it is easier for teachers to have a progressive weakness of the frame than the classification. This means that these teachers more easily worked with students in group work, promoting students discussions and developing a student centred approach, than were able to not keep the sequence of the mathematics topics. Even in some cases those teachers who promoted problem solving to approach some subjects of the curriculum, followed the sequence of the syllabus and needed to have lessons to teach them.

The fact that some teachers (Category B) did not like students being in different phases of attainment of their tasks could be explained by their loss of control of what students were learning, and whether all of them could do all the tasks proposed. As Bernstein states "The underlying theory of learning of llection is likely to be didactic whilst the underlying theory f learning of integrated codes may well be more group or self-egulated" (p. 102). The teachers of category A did not dare to se computers within the classroom as they felt that computers ould be an obstacle to developing the lessons as they usually id, maintaining the sequence of the subjects and the order, and he reasons they gave showed them to have an underlying theory of earning collection (even if implicit). This can be confirmed by he fact that some teachers showed a more integrated type of urricula in the computer club. Teachers of category C, mainly oana, revealed an underlying theory of learning integration. hey did not seemed worried with the boundary of content, even with the boundary between classroom and club. They let students have power in the development of the work, respecting each group and each student pace, and several times they referred to how they thought it important to increase the autonomy of students.

CHAPTER 7

TEACHERS' EVALUATION OF THE PROGRAMME

7.1. INTRODUCTION

One purpose of this study was to understand how teachers viewed their own development through attendance at the in-service teacher training programme. Also teachers' opinions concerning the different components of the programme were sought in order to perceive teachers' needs for adapting the programme to teachers' work with students, as well as to introduce further improvements in future programmes.

This chapter has two main parts, the first concerns teachers' views about the influence of the programme on their professional development; the second reports the results concerning which aspects of the teacher training programme were most valued by teachers.

7.2. TEACHERS' VIEWS AND PERCEPTIONS OF THE INFLUENCE OF THE PROGRAMME ON THEIR PROFESSIONAL DEVELOPMENT.

During the first year of the field work, teachers were formally invited to express their opinions concerning the training received, and about aspects related to their professional development by means of a questionnaire and an interview, as was explained in the methodology chapter. The mathematics teachers were interviewed twice more during the second year of the field work.

) Just at the end of the first school year, when the training ogramme was over (3rd questionnaire, annex C);

) At the end of the teacher training programme (first interview, nnex F, item 7);

) At the end of the second school term of the second year second interview, annex G, items 1 and 2, only for mathematics eachers); and

) At the end of the second school year, after the summer holi-ays (third interview, annex H, item 3, just for mathematics eachers).

The methodology adopted to gather and analyse this data is described in a more detailed way in chapter four.

7.2.1 The questionnaire

The questionnaire (annex C) was distributed to all the teachers involved in this programme (29). A total of 22 questionnaires were returned. The first question in the questionnaire provided information about the way that teachers viewed the contribution of the teacher training programme to their improvement in ten specific areas (A-J), requiring teachers to respond to specific items in level of preference.

Table H shows the frequencies of teachers' answers to the questionnaire. The highest level of contribution was **"the development of an attitude of permanent learning"**, with 20 "high responses", followed by **"the development of a capacity for research regarding the gathering, organisation and presentation of information"** with 17 "high responses". With 14 "high responses" we can see the **"awareness of the importance of intrinsic motiva-**

on in knowledge acquisition", and "the development of a new lationship with students".

The "development of the ability to stimulate and support e students' projects" and "the development of new perspectives ncerning the role of the teacher in the school" had 11 and 12 igh responses respectively. Less than an half of the total of he responses had "high" in the following areas: "to view knowl-dge in an interdisciplinary way" (8), and "The awareness of the roblems of communication in the school context" (3). The areas , D, had two "low " responses and E, G, and I had 1 "low" esponses. One teacher didn't answer to the E and I questions.

ble H: Frequencies of teachers' views concerning the importance the activities developed and their contribution to improving e quality of their work.

	High	Moderate	Low	I don't know
. Development of an attitude permanent learning	20	2	-	-
. Awareness of the importance f intrinsic motivation in nowledge acquisition	14	8	-	-
. Development of the capacities f organisation and techniques f team work	12	8	2	-
. To view knowledge in an nterdisciplinary way	8	12	2	-
. Development of a more ositive perception of your unction as an educator (a)	10	10	1	-
F. Development of the capacity for research regarding the gathering, organisation and presentation of information	17	5	-	-
G. Development of a new relationship with students	14	7	1	-
H. Development of the ability to stimulate and support the students' projects	11	11	-	-
I. Awareness of the problems of communication in the school context (a)	3	17	1	-
J. Development of new perspectives concerning the role of the teacher in the school	12	10	-	-

(a) One teacher did not respond to this question.

As these results were gathered by means of closed questions, ey guided the teachers' answers, and they need to be discussed gether with other data gathered. However they showed that the fferent items had different levels of importance for teachers, for instance the fact that almost all respondents placed "the velopment of an attitude of permanent learning" in a high posi- ion. The level of responses to this item was surprising, and ecause of the closed nature of the questionnaire it was diffi- ult to interpret teachers' reasons for this response. Probably his result was due to the fact that the teachers were learning bout computers, which was a very new subject for them.

The seventeen high responses on "The development of the apacity for research regarding the gathering, organisation and resentation of information" was probably due to the Work Project that they were developing during the first phase of the pro- gramme.

It seems significant that most teachers chose relationship with students, and motivation for learning. In fact they soon began working with students using computers (see chapter three). This result is consistent with other data, mainly data gathered through informal conversations. Teachers often talked about these aspects, wondering how most pupils were engaged in tasks involv- ing work with computers, and how their relation with them was different from the usual relationship within the classroom:

> "...I feel myself closer to my students, when I go to the computer helping them, discussing how this or that can be better be solved" (field notes, 3/5/89).

"It is amazing how some students have a special aptitude to work with computers; They easily overcome difficulties with computers, even some weak students, and sometimes faster than me" (field notes, 14/2/89).

"Usually students become very happy when the class is over, now they continue attached to the computer and they forget the interval" (field notes, 15/5/89).

The aspect of some teachers feeling themselves "closer" to udents, may be also due to the fact that they were implementing ojects with students, which they were not used to doing. This s selected by eleven high responses to the items H and J of the uestionnaire.

In summary the results of this questionnaire seemed to eveal that the practical experience which teachers were going hrough with students during the course was considered positive y them, and had contributed to the improvement of teachers' wareness of certain aspects such as the importance of student otivation towards school work, and the relationship between eacher and student. From the perspective of personal improvement, teachers seemed to have enlarged their view concerning their role as teachers.

.2.2. First Interview

At the end of the teacher training programme nineteen of the teachers involved were interviewed. This group included all the athematics teachers. It was my intention to include in this group also primary school teachers and teachers of several disciplines.

This interview (annex F) took place at the end of the programme, so that the following results were arrived, at in a difrent way from the questionnaire. The seventh question of this terview was an open question, just asking teachers to suggest e effects of the programme on their teaching/learning process: uring the last year you have been developing a lot of work: ork with students, attendance at teachers' workshops and semi- ars, exchange of experiences and ideas with colleagues. Do you hink that all this work, in some way, has affected you in your onceptions of or attitudes to the teacher's role and the student earning process?"

Seventeen (out of nineteen who answered the interview) :eachers responded "yes" to this question, mentioning the parts of the teacher training programme which they considered to have ıad most influence in their professional improvement, or to which :hey gave more value in some way. The results related to the lifferent components of the programme, and a discussion of these in relation to the different ingredients of the course can be found on this chapter.

These seventeen teachers recognised effects of the programme on their views of the teaching/learning process (see table I), reinforcing their own beliefs or opening new perspectives. This table is divided into two parts, since through the analysis of the teachers' answers two aspects became evident: the influence of the programme on teachers' ideas and beliefs and the influence on teachers' actions or intentions to act in a different way with students.

Only two teachers were not very explicit in an affirmative answer, concerning the influence of the programme on their teach-s' role and learning process, like this teacher who said:

> "I don't feel myself to be completely the same, but I cannot say that I have changed very much. I feel a need to know, to put all these things I have learnt into action, so I can use them better, that means, I have little practice. I feel the necessity to stop, to reflect, to try new things" (Dina, Mathematics teacher).

The other teacher reported that:

> "This helped me and it obliges me very much to reflect about some aspects of the Social Studies curriculum. Related to the student learning process it doesn't change me very much, but this aspect is very subjective. I always have had a good relationship with my pupils, so I don't give this credit to the work with the computer, because in other cases I have a good relation, perhaps having a stronger attachment with the experimental class" (History and Social Studies teacher).

In spite of not seeming to recognise a direct influence on their practices, these two answers at least indicated a need for reflection after this new experience of introducing computers in their professional practices.

ble I: Teachers' views of the influence of the programme on eir ideas about teaching and intentions to work in a different y with students. N=19.

achers' ideas about teaching	**Frequencies**
inforcement of their own eas	5
udents' interests are ndamental to learning	3
tudents can be more autonomous n the learning process	3
e should respect each student's pace	2
he importance of school "dynamisation"*	2
ew organisation of student work	1
here are new ideas to solve ome pedagogical problems	1
he change in the conception of what a lesson should be	1
The importance of students having a common project	1
Teacher student relationship	1
Teachers' actions or intentions to act	
Program classroom work in a different way looking for new strategies	5
Devising new things	2
Promote problem solving situations	2
Promote student group work	1
To have more freedom related to the independence of the mathematics syllabus	1

* "Dynamisation" is a set of extracurricular activities involving students and teachers.

Five teachers expressed the opinion that all this work uring the year had had the effect of reinforcing their ideas bout teaching and learning and had in some cases helped them to ut into practice what they already assumed in theory. The athematics teacher who had already worked in MINERVA the year efore, said:

"Before having worked in the Minerva Project , I already thought that students could be successful in Mathematics if they are really interested in the work, but in practice I never have found the way to stimulate students by the necessary inducement. On the other hand I already thought that each student should pursue his own way of learning, each student should follow his own pace and should get used to organising his own work, should discuss ideas with school fellows, should get used to depending on his/her point of view about a subject, should be able to criticise his work,...but I thought that in practice it was practically impossible to accomplish all of this. It was through this year, and as result of the training received and the exchange of experiences with my colleagues, that I began to try to put into practice this kind of work. I think that all this year has given me the incentive that I needed in order to put into practice certain ideas which I already held in theory".

A primary school teacher who worked with students with special needs states:

"...I have to reflect on a new way of organising student work, and I have reinforced something that I already knew, but now I am sure: the students' interests are fundamental to their learning".

A teacher of History answered this question saying that:

"I think that a person is continuously advancing and developing and essentially there was no great difference, because my idea of teaching and learning was already formed. Anyway, I think it has been important, because there were some issues which were studied, reflected upon and then it seems to me that a certain maturity of concepts that sometimes were completely forgotten has been provided, and this way the dialogue and familiarity through a year was really important to raise some pedagogical issues, and even to solve some problems. But this year's experience was really important on that aspect, because we have taken out again some issues which were definitely put away in the drawer. ... This aspect of being both teacher and student at the same side was to me the biggest surprise, because I have never been in such a situation before. This work was totally new, although I had worked by team work and had promoted some investigation by children, but in the past the role of the teacher and the role of the student was more clear. Now it is different since I discovered new things, the relationship between me and students has changed very much".

Some teachers considered that this year helped them to be ware of student aspects such as the importance of students' nterests in their learning, and independent work:

"Do you know? I was persuaded that I didn't centralise the classroom work, but perhaps I did. It made me see things which I never had thought before. I believe that with computer work I will be able to modify my behaviour in some aspects that I never thought before. I understand now that children alone go far, and I never imagined that this might be possible. Now I am trying to be quieter within the class, and with the computer this is easier than without the computer. The team work was also a very good experience for me. The fact of children having a common project has a good influence on them" (Catarina, Mathematics teacher).

"... Now I feel more confident in the classroom and I have come to a new position, since I foster independent work by students, and I assume that they are able to overcome alone a great part of the difficulties" (Berta, mathematics teacher).

"It fundamentally affected me in the aspect that I told you about before; to value independent work, such as problem solving situations. I was already aware of this issue, but all this work this year made me see that the computer may provide independent work by the student, and I would like to carry on and to become sure, since at this moment I still feel anxious. Now it becomes clear in my mind that problem solving situations are fundamental to students' learning of mathematics. All the independent work in which the computer is used like a tool, like anything else, where the children or the group have to organise the work in their own way, and the content is studied when the need arises, that I did not have very clear in my mind and the computer has helped me to reflect" (Carla, mathematics teacher).

Two teachers valued the school "dynamisation", that is a rtuguese designation for the set of activities and projects, ainly the interdisciplinary ones, which involve the whole chool, or just some interested teachers and students. This spect was noted by a mathematics teacher who reported:

"I never thought before, in terms of school "dynamisation" that so many people might be involved, as during this last year. I could verify that being in school may be different and that students may enjoy going to school. I think that everything surprised me. This work obliges a person to go constantly onwards, we cannot stop. Everyday there are new things, even an answer that a student gives us. The exchange of experiences is always positive, it is discussing with other people so that people are improving their work" (Joana, mathematics teacher).

The following answer showed that the computer is recognised as having an important role in the impact that this program has had on some teachers:

"This work has enriched me, since it made me meet with other people who are working on the same things as I am, exchanging experiences, discussing issues we have in common, using some materials, such as spreadsheets. This kind of work was unfamiliar to me, and I think that with team work everybody gains something. I have changed the way I teach, even my conception of what a lesson should be, and I believe that I have changed for the better, having the goal of an improvement in teaching and learning. There is no doubt that the computer is at the centre of all this (Paula, mathematics teacher).

These answers reveal that teachers had a general notion of ome differences in their ideas about teaching, but it was not asy for them to be very specific about concrete changes in their ractices, as it is shown by these statements: "It made me see hings which I never thought before", "I discovered new things, he relationship between me and the students has changed very uch". However some of these teachers mentioned aspects such as **'Program classroom work in a different way, looking for new trategies", "value independent work by students" and "problem olving situations",** what shows that some teachers recognised some effects on their teaching styles, after this year. Other teachers focused on this programme providing the concretion of aspects that they already thought to be important to students such as students' autonomy, and engagement in the learning process.

7.2.3. Comparing the results of the interview with those of the questionnaire

Data gathered through the questionnaire and by means of the interview showed some differences since with the questionnaire the teachers were forced to consider specific aspects given by the items. During this first interview nothing was directly asked about change in their practices, but only the effects on their ideas about the teacher' s role and the student learning process, after this new experience of introducing computers in their professional practices. The aspects focused on in the interview seemed to be more related to teachers' awareness of students, (e.g. "students' interests are fundamental to learn-g", "students can be more autonomous in the learning process", tudents' pace"), and also on the need that teachers were feel- g to look for "new strategies" in their work within the class- om. Aspects given value in the questionnaire such as "develop- ent of an attitude of permanent learning", or "development of he capacity for research regarding the gathering, organisation, nd presentation of information", could be related to the will hat teachers showed to change the work within the classroom, but t also could be justified by their own learning about computers s well as the work project developed during the first phase of rogramme, since they had to learn new things. However other tems of the questionnaire such as "the awareness of the impor- ance of intrinsic motivation in knowledge acquisition" were also approached by teachers during the interview.

7.2.4. Analysing the mathematics teachers concerning their views about the effects of the programme on their professional development.

During the second year of this study the mathematics teachers were asked about their opinions concerning the effects of the programme, and the work that they were developing with their students using computers, on their professional development.

7.2.4.1. Second interview, middle of the second year.

The eight mathematics teachers were also interviewed in March 1989, when they had been working with students for about six months, in the second year of the study. Through this interew (annex G), the teachers were now asked if they thought that ey were using the same methods with students as they had used fore, and if there had been any changes.

These questions aimed to understand whether the teachers re aware of changes in the methods that they had been using th students, even without computers. Five of these teachers nsidered that they had changed, one teacher said that she idn't know, another that she was using the same methods in the lassroom that she had used before. Finally one teacher reponded that her methods were not very different, but pointed ut several modifications in the way in which she was now working ith the students:

> "What is different is the work that the students do. Students used to work at the same activity, and now I have students doing different things. Now this work has more value, since I prepare more problematic mathematics activities for them, I prepare some working material as worksheets and I prepare some instructions for the LOGOWRITER, and what I feel is that more and more I am improving my suggestions for the students' work... usually I have put students in groups, but now I also promote student discussion, perhaps because the activities are more problematic." (Joana)

Four teachers indicated, as the main difference in their methods, their implementation of simultaneous diversified activities in the classroom. However two of these teachers (Carla and Ana) stated, in the third interview (annex H), that if they could have had enough computers available, they would have preferred to have all the students working at the computer at the same time. Four answers mentioned group work. These results were expected inasmuch as six of the teachers were experimenting in using the mputer in the classroom, developing diversified activities and udents group work. Three teachers considered that they now omoted more student participation in the development of classom activities, and more independent work by the students. One acher noted that "I felt a need to control the students' work, d now I give them more freedom on the team work" (Catarina). wo teachers said that now they gave more importance to problem olving activities, as well as to student discussion, and another wo answers mentioned the need to look for new strategies in the lassroom. The teacher who was working with computers only in lub situation, responded "I don't know" and added that:

> "Perhaps I have another perspective on things, but I don't feel aware of great alteration. In the classroom I work with two students at each table, but it is not group work. In the club it is different, they have their projects and there I guide them" (Dina, mathematics teacher).

Table J summarises the aspects that teachers mentioned related to their changes in mathematics teaching.

ble J: Aspects focused on by teachers concerning changes in eir teaching in the end of the second school term of 1989

pects focused on	**Frequencies (N=8)**
plementation of Diversified tivities in classroom	4
oup work	4
re student participation	3
re student autonomy	3
oblem solving situations	2
tudent discussion	2
earch for new strategies	2

In summary, one year and an half after the programme had egan, most of the mathematics teachers (5) recognised a certain hange in their methods, mainly related to **group work, diversifi-ation of activities, more problem solving, and more student nvolvement in the development of class work.** One teacher did not recognise a great change, but when she elaborated on this in her conversation she talked about several aspects which were new (or different) in her practice as a teacher. The two teachers who were not working in curricular activities with computers, but only in a club, did not refer to any difference in their methods in classroom work or gave "don't know" as an answer. The reasons reported by these two teachers for not using computers within the classroom are different. One stated that she had a programme to accomplish, and that she was waiting to see the results of expe-riences of the other teachers, and then try to introduce the mputer into the classroom. The other teacher claimed that she d not have any specific software to approach the mathematics ntent.

Comparing the teachers' answers at these two stages (end of e first year and six months after of having been working with udents in the second year), it seems that most of them recog-sed some change in their ways of working with students, after ese six months of work, or they were able to specify what they d changed in a more concrete way. The aspects related to class-om management (diversified activities, problem solving, and oup work) were more frequently mentioned perhaps because they re underlying a new experience in the classroom approaching the athematics content with computers, and these were the aspects ost evident and discussed among them. However this kind of work eems to have had some influence on their teaching styles even in lasses working without computers.

.2.4.1.1. Teachers' views concerning the assessment of the stu-ents

In informal conversations some teachers talked about the ssessment of the students. Some of them referred to the fact hat some weaker students were on the computer doing work that as equal to or even better than the best ones. As they were orking in a different way within the classroom, it seemed impor-ant for me to talk to them about this issue during this inter-iew. So, through the fifth question of this second interview, ata was gathered in order to understand if these teachers had aised some issues related to the assessment of the students, nce they were working with computers to approach parts of the thematics curriculum. Only six teachers answered this question the other two were not using computers in the mathematics lassroom.

Four teachers responded "no" to this question. However only ne said that she was using the same students' assessment process hat she always did, that is by tests. The other three teachers onsidered that as they knew the students better the evaluation as easier, as for instance :

> "...Now I know my students better and I do not overvalue the tests as I did before, but I have to discuss this fact with them, because they used to compare the period scores with the tests scores, and they might feel some injustice" (Joana).

> "Now the way I evaluate the students is different, since I do it during the whole process while they are working. I also do tests, but I also observe their progress, and for me this is most important. Usually I do a feedback together" (Catarina).

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Two teachers expressed some concern about this issue. They said that this was a question that they needed to think about, as for instance Berta, who added that:

> "I have to assess them in everything, and I am aware that I do not know how to do it very well. I do tests, but they have a less importance now. I only put questions about mathematics and nothing about computers. I don't know if this is right. The tests can seem to be traditional, but I try to put questions which will enable me evaluate the way by which they found the solution".

The students' assessment issue was one aspect that teachers re modifying in their teaching styles, or at least an aspect ich they were thinking about. However this was not explicated ring previous answers in the interviews, except by Carla who d referred to this aspect in the first interview.

2.4.2. The third interview

This open interview (annex H) took place in October 1989, the beginning of the third year in which these eight teachers re involved in the MINERVA project. This interview also had the jective of collecting more data about the thinking of teachers oncerning the influence of the two years of experience using omputers, which they were developing over two years, in their ole as educators and mathematics teachers. The intention was to hrase a question in such an open way that the answer could not e influenced by the question. In the second interview the ques-.ion: "Do you think that you are using the same methods with ;tudents as you used before?" suggested the specific work within :he classroom. The question in this final interview, that is :"Did computer work with students help you to clarify your role ıs an educator and a mathematics teacher?" aimed to give the ›pportunity to the teachers to say something more deep or global, ıainly so that they could choose the aspects on which to focus, ›robably those that they feel most related to their own develop-ıent. To this question two teachers answered "very much", five :eachers "yes", and one teacher said "a little". The following :able provides data that illustrate the aspects that teachers :ocused on their answers. Through content analysis of the re-;ponses three categories seem to be apparent: aspects related to eachers' practices, aspects related to teachers' beliefs, and eneral aspects related to the professional improvement of eachers. Each teacher who responded focused on two or three of hese aspects.

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ble L: Teachers' responses concerning the clarification of acher's role as an educator and as a mathematics teacher.

eachers' practices	**Frequencies**
xperiment with new ways of approaching aths in classroom	4
romote more problem solving	3
odify the organisation of classroom	1
romote more student participation	1
ive more time to the students to work n Maths.	1
eachers' beliefs	
tudents can learn Mathematics nd can discover things on their own	2
Students are creative	1
Students need time to work on Maths	1
Students need to be engaged to learn Maths	1
Teacher student relationships in the learning of mathematics can be closer	1
Teachers' personal aspects	
Importance of teacher's reflection	2
"This experience pushed me"	2
To become updated	2

These answers seems to reveal that most of teachers considered that the work in MINERVA had had some influence on their perceptions of their role and the role of the student in the learning process, on their awareness of some pedagogical issues, and on the need to reflect and re-think their own teaching styles. Some teachers were more explicit concerning this influence than others, such as Catarina (more student participation), Carla, Berta and Joana (more problem solving) and Joana (students are creative and they need time to discover mathematics). All the other teachers mentioned broader aspects such as reflection, re-thinking, experiment with other things. Probably the first three teachers had developed a clearer idea of their own development than the others, who felt the need to consolidate aspects which were appearing in the concrete experience that they were undergoing.

7.2.4.3. Teachers' views about the effects of the programme on their professional development and the chapter six categories .

Through a horizontal analysis of the data gathered in informal conversations and formal interviews from these eight mathematics teachers (see annex MT, where teachers are described in detail), I searched the aspects most frequently referred to by them during these two years, concerning their views about their own development. This analysis was needed, since the issue of teachers' development was approached formally by means of different ways of putting questions. Also the timing was different, and teachers probably were influenced by the work they were developing at the time of the interviews. The following table displays a synthesis of the aspects more often focused on by these teachers:

Table M9: Eight mathematics teachers' views concerning the most important effects on their own improvement.

Aspects focused	Teachers							
	Ana	Paula	Catar.	Carla	Dina	Susana	Berta	Joana
Learn and experiment with new things	X				X	X		X
Problem solving			X	X			X	X
Indep. work by students			X	X			X	X
Students' motivaton	X			X	X		X	
Team work		X	X	X			X	
Student discussion			X					X
Act. role of students in the dev. of maths activ.			X	X				X
Need for reflection on pedag. issues		X		X	X		X	
Do not feel the need to control the class			X					X

This analysis, in comparison with the previous one, showed that problem solving, independent work, active role of students, team work, experimenting with new strategies in mathematics classroom, need for reflection and the awareness of students' motivation for learning, were the aspects most cited by mathematics teachers throughout the two years.

Relating this analysis to the three categories of the mathematics teachers delineated in chapter six, it was possible to find some relation between teachers' views concerning the most important effects on their professional development and these categories.

Category A: Teachers who did not introduce computer activities within the mathematics classroom.

The two teachers, Dina and Susana who are in this category only indicated "to learn and experiment with new things". Dina also mentioned "students' motivation", and "the need for reflection on pedagogical issues". However Dina mentioned sometimes the importance of students' discussion but she only recognised it when they were involved in developing projects in the computer club.

Category B: teachers who introduced computers within the mathematics classroom.

The four teachers of this category are Paula, Ana, Carla, and Berta, who developed systematic work with computers inside the classroom teaching curricular topics. "Problem solving", "independent work by students", "team work", "students' motivation", and "need for reflection on pedagogical issues" were mentioned by Carla and Berta. Paula showed a "need for reflection on pedagogical issues", and Ana only focused on "students' motivation" and "to learn and experiment new things". Carla also mentioned "active role of the students in the development of mathematics activities", and Paula "team work".

Category C: Teachers who developed more free work in mathematics classroom.

There are two teachers in this category: Catarina and Joana. They were the two teachers who referred to "promote students' discussion", and "do not feel the need of controlling the class. These aspects were not valued by their colleagues. "Active role of students in the development of classroom work", "problem solving", and "independent work by students" were also mentioned by these teachers. Catariana also indicated "team work", and Joana "to learn and experiment with new things".

This categorisation showed that the two teachers who did not choose to work with computers within the classroom only focused on aspects concerning the learning and the experience with new things, and one of them indicated students' motivation and need for reflection. It suggests that they did not consider changes related to their pedagogical practices. In spite of both teachers recognising that they had learnt and experimented with new things, and never had worked with computers within the mathematics classroom, there were some differences between them. Dina was aware of the importance of students' engagement in projects, which she developed in the computer club. She also told several times about the easy and powerful way provided by LOGO to learn some concepts of Geometry, and she expressed the will to begin to work within mathematics classroom with computers, which did happen in the following year, after the field work of this study was completed.

The teachers of the category B gave emphasis to other aspects such as problem solving, independent work, team work, active role of students in learning process, and students' motivation. Two teachers of this category also accentuated the need for reflection on pedagogical issues. These four teachers worked within the mathematics classroom using computers. Some of the activities were very structured, and they felt the need to give lessons in order to systematise the subjects (see chapter 6 and annex MT).

The teachers of the third category were the only ones who mentioned no need of feeling in control of the class, and they gave importance to students' discussion within the mathematics classes. They developed open problem solving and investigative activities, and they did not seem to be concerned with the sequence of the mathematics subjects of the curriculum, as well as with the differences of attainment of the tasks by the students.

Some relationship was found between the categories defined in the previous chapter and teachers' views about their development. The differences concerning the emphasis that these teachers gave to the effects of the programme on their professional development, indicates an interaction between their practices with students and the aspects which were more focused on by them in conversations and formal interviews.

7.2.5. Global discussion

The intention of the first part of this chapter was to analyse the effects of the in-service teachers training programme from the point of view of the teachers involved. As was explained in chapter three, it was my intention that the major part of the programme occurred at the same time as teachers were developing school activities with students using computers, which meant that concrete practice became part of the teacher training rogramme itself. This analysis began from when the programme was eing developed until the end of the following school year. In fact teachers' experiences with students during this second year, had probably influenced teachers' answers to the second and the third interviews. According to some authors (e.g. Easen, 1977, and Law, 1989), teachers' development is directly related to teachers' practices. Also teachers' development in the process of changing their practices, is closed related to teachers' views about their role and the students' role in the learning process as well as to teachers' views about the curriculum (Erault, 1977, Calderhead, 1987, and Blackman, 1989). Fullan (1982) and Erault (1977) state that change is a process; teachers need time to assimilate innovative ideas, to integrate new knowledge, to implement new methods and to assume new roles in their professional practices.

To understand the effects of the programme on teachers, it was more important to study what teachers did in real educational contexts, than simply what teachers said. As was found, mathematics teachers revealed different paths of development showing different ways of integrating computers in educational contexts. This part is explained in chapter six, for the mathematics teachers only. The three categories defined in the previous chapter distinguished teachers according their attitudes and practices towards the use of computers approaching mathematics. It seemed that teachers who developed open activities, letting the students having power in the development of the work, respecting each students's pace, and defending the idea of students' autonomy, ere those teachers who considered that they improved in promot-ng students' discussion and that did not feel the need of con-rolling the class as they did before. Teachers who promoted a re structured work and were more concerned to the boundary of athematics contents, considered that they increase their capaci-y to implement problem solving, team work, and independent work, roviding a more active role of students. The teachers who did ot chose to use computers within mathematics classroom only ocused on aspects such as the learning and experience of new hings and students' motivation.

Previous personal and professional experiences influence rofessional teachers' development (Blackman, 1989). The impact f the training programme on teachers is related to teachers' ast experience, their educational philosophy, knowledge (for nstance Fullan, 1982, and Hargreaves, 1989); this means that the onsequences of this experience did not affect all teachers in he same way. Rudduck (1991) says that teachers need opportuni-ies to reflect on their own past experiences in order to become ble "to reaffirm or to restate the principles that guide their ractice" (p. 91). Five teachers in this study explicitly stated hat the programme had the effect of reinforcing their own ideas nd beliefs. This aspect is also approached by Brown (1988), who entioned the importance of providing teachers with "stimulating xperiences which are likely to give rise to reflection and econstruction of beliefs" (p. 8).

Van Manen (1977), cited by Zeichner and Liston (1987), dentified three levels of reflective teaching. At the first evel the main concern is with the efficient application of ducational knowledge for the purposes of attaining ends, which re accepted as given; at the second level of reflectivity, eachers are concerned to explain and clarify the assumptions nderlying their pedagogical practices and to assess the effects n students; and finally at the third level critical reflection aises moral and ethical issues such as "whether current arrange- ients serve important human needs and satisfy important human ɔurposes" (p. 43).

Teachers underwent this new experience of introducing com- ɔuters in educational activities, which made them reflect on new issues: "I had to reflect on a new way of organising student vork", (first level), "this helped me to reflect about some ıspects underlying the Social studies curriculum", "this year vas really important...we had taken again some issues which were lefinitively put away", and "...the computer helps me to reflect ıbout pedagogical issues" (second level of reflection to clarify :he assumptions and predispositions underlying practical ıctions). The process of reflection upon teachers' actions is ılso stressed in literature, for instance by Schon (1987) and Easen (1977) "challenging familiar assumptions, ...exploring new vays of acting" (Easen, p. 71).

Another aspect of these findings is the focus that teachers ɔut on personal aspects of their professional improvement (see tables I, J, and L). These results are in accordance with some studies found in literature, (for instance Halpin, Croll and Redman, 1990). These authors found that as a consequence of INSET, teachers tend to be more aware of aspects at the level of ndividual knowledge and teaching approaches, such as planning etter schemes of work with students, discussing about common roblems with their colleagues, developing teaching skills and eepening their knowledge about educational issues. Also Dean (1991) considers the challenge to professional skills by an ducational problem or a new task, as one of the factors which is responsible for teachers searching out opportunities for their own professional development. The MINERVA project asked for teachers who wanted to experiment with the new pedagogical device in schools: the computer. It is probable that teachers chose to be involved in MINERVA, for one of the reasons pointed out by some authors concerning the stages of teacher professional development, such as "the mastery stage" (Watts, 1981). All of the mathematics teachers had twelve or more years of experience and perhaps they, as mature teachers, felt the need to rejuvenate and to go out of a professional routine, looking for new challenges (Watts, 1991). The positive predisposition of these teachers can explain the fact of all teachers had considered some improvement as professionals. However the impact of the programme, as well as the work developed using computers had different effects on teachers, as they were different people, and had different past experiences. These findings are integrated with those of other chapters in chapter eight.

7.3. TEACHERS' OPINIONS OF THE DIFFERENT COMPONENTS OF THE PROGRAMME.

This second part of chapter seven concerns teachers' opinions about the teacher training programme in which they were involved. Teachers' opinions were mainly gathered during its development through two questionnaires (annexes A and B), and at the end of the school year by means of another questionnaire (annex C) and an interview (annex F). Also informal conversations were taken into consideration during the development of the course as well as during the second year.

7.3.1. The most valued components of the teacher training programme during the first phase

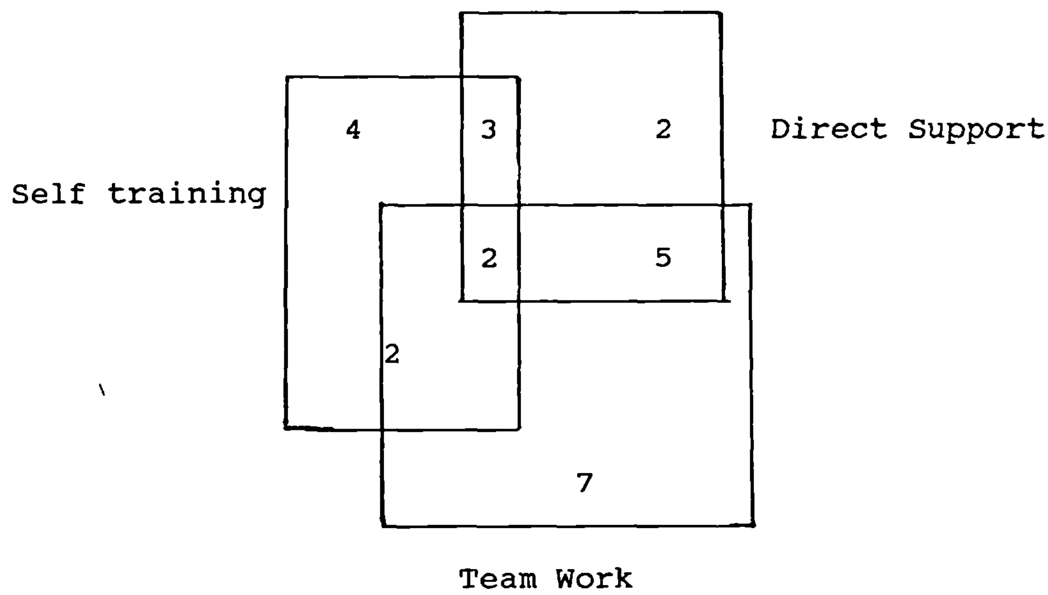
Teachers were asked to give their opinion about the different training experiences of the first phase of the programme (see chapter three). The anonymous questionnaire was answered by twenty five teachers. One of the open questions was:

"From all the work developed in this phase which was the most important aspect for you? (Direct support, self training, team work, etc.). I did not want to ask directly "did you prefer the work project or technical training", since my intention was to understand the importance of both technical and work project aspects, without setting them in opposition. Teachers mostly worked in groups during this phase when they were developing the work project. Self training (teachers learning about technical aspects without the presence of the teachers educators) and direct support (teacher educators went to teachers' schools helping teachers working with computers) constituted most of the technical activities for teachers.

Only the aspects cited as examples in the question were referred to by teachers: direct support, self training and team ork. The frequencies were as follows:

eam work	Direct Support	Self Training
16	12	11

Most of the teachers referred to more than one aspect as he following diagram shows:



Most of the teachers found team work to be a very positive experience, direct support and self training coming second. However, since the fact that direct support and self training were more related to technical aspects of the programme and team work was more related to the work project, teachers most valued the technical training (23 references: 12 direct support plus 11 elf training). Nine teachers did not refer to team work as an mportant component. Those who valued this aspect said that it as due to their **interchange of views, support and incentive, ivision of tasks and exchange of experiences.** They also stressed he importance of the work developed during the first phase since 'the interaction of a dynamic group in school created both en- ouragement and dynamism as well as a richness of situations".

> "We did not know each other and working together it was possible to exchange opinions, to support each other and so we developed good work".

> "It was the team work that enabled us to accomplish the work project, as there was a coordination of the tasks among us".

With regard to self training a teacher stated: "It helped me to overcome a certain insecurity I felt towards the computer"; another one wrote "without some effort and personal concern no results are achieved".

> "Self training and team work allowed me to get some control of the technical aspects of computers and to lose the inhibitions I felt in the beginning. The team work gave me stimulus and support".

Teachers were also asked to describe the negative and positive aspects of this phase. Through the analysis of the responses, two different kinds of points were considered as negative: some extrinsic and some intrinsic to the training programme, as is shown in the following table.

able N: Teachers' opinions concerning positive and negative spects of the first phase of the programme.

egative aspects	**Frequencies.**
xtrinsic	
ncompatibility of teachers' timetables	4
ack of equipment	4
ittle time free of classroom work	3
oor conditions in school	1
ntrinsic	
ack of training approaching the use of omputers in curricular areas.	4
Little technical training	4
Little time for exchange of views regarding conceptions of learning	2

Note: One teacher also replied that "the work of project superseded the work with the computer".

Positive aspects	**Frequencies**
The possibility of using new strategies in teaching, discovering the potentialities of computers.	9
Exchange of experiences	7
Project Work	6
Self training	5
Team work	3
Possibility of using the computer in school activities	2
Contacts with teachers from other schools	2
Availability of the teacher educators	1

Related to the work project component of the programme a etailed analysis was written in chapter five concerning the eachers' reactions to this proposal. Six teachers did not seem o understand why they had to develop such work when they had so uch to learn about computers, but most of the teachers expressed heir interest in doing it. This experience was specifically entioned as positive, in this questionnaire by three teachers, s for instance these sentences show:

> "interesting for its methodology and characteristics which enabled the whole process they had been through and the results obtained which would not have been achieved otherwise".

> "... the team work and the conviction that it is possible to do a lot more, the joy of having accomplished work which was pleasant although somehow tiring".

When teachers were asked to give their opinion and suggesions concerning the aspects which they though must be included in a teacher training programme for teachers who would be starting to work with computers with students (5th and 7th questions), teachers gave great importance to the technical training. However some teachers stated that training for this kind of work also required a deep knowledge of other experiences about the educative use of computers, already gained in other schools and countries. Discussions about the pedagogy of the use of the computer should also take place. It was also mentioned that the training should enable the practice of research into, and investigation and group discussion of, pedagogical aspects.

The following table shows the frequencies of the most impor-ant components considered specifically to be required in a eacher training programme for teachers involved with computers n education (frequencies of the answers to the two questions entioned above were added).

able O: Components of a programme for teachers involved with omputers in education: teachers' opinions

edagogical omponents	Technical components	Curricular components	Information about national and international experiences
22	31	15	15

Some of the pedagogical aspects were specified: psychology, ociology, group dynamics, research and experimentation. Other eachers only referred to the sciences of education or pedagogy.

Some teachers' sentences can illustrate that both technical and pedagogical components were considered as important for inclusion in the programme:

> "The technical aspect is important, but it is not enough to use a computer in a pedagogical sense, so I think that both components should be present".

> "In spite of the fact that pedagogical training is important, a more specialised training should be included"

> "Moments of reflection, group discussion concerning the affective and the psychological aspects of the use of computers in the classroom, as well as discussion about the best software to be used, are very important".

> "Weekly seminars exploring and discussing useful software to be applied in the several disciplines within the classroom, will be accepted by all teachers with satisfaction".

Two teachers also suggested that a complete technical training should take place before the work with computers began in school, and only one teacher referred to the "need to learn programming to use the computer in school".

7.3.1.1. Summary and Discussion of the Results so far

As described in chapter three, during the first phase teachers attended technical workshops, but they were mainly engaged in a work project concerning the introduction of computers in schools (its development is described in chapter 5).

In this first phase, almost three months after the teachers training programme had started, most of teachers seemed to have a preference for the technical training received. This fact was even noticed when teachers talked to me and to the other teacher educators about their lack of knowledge about computers. This insecurity towards work with computers seems natural, especially because teachers were asked to begin working with students straight away. Even so a great number of responses to this questionnaire focused on pedagogical aspects, which seems to reveal a certain awareness that to integrate computers in educative practices it is not only necessary to know how they work.

One of the components most appreciated by teachers was the moments of team work, sharing their work and ideas, and also "the support and incentive" from one to another.

Comparing the positive and negative aspects (see table N) I could see that teachers considered more positive than negative the work that they had experienced so far, mainly the aspect of discovering the potentialities of computers in order to use new strategies in teaching.

7.3. 2. Teachers' opinions about the different components of the programme during the second and third phases

Data was gathered by means of two questionnaires (annexes B and C). The following table displays the training activities which were considered most important after the second part of the programme, by the twenty two teachers who responded to the questionnaire.

Table Q: The most valued components of the programme at the end of the second phase.

Components of the programme	Frequencies
Techn./Pedag. Seminars	13
Pedagogical exploration of certain programs	13
Exchange of experiences	10
Visit to schools	8
All of them	4

.3.2.1.Exchange of experiences/visits to schools.

Most of the teachers's answers stressed the importance of he exchange of views, by means of specific seminars devoted to his, or during visits to each other schools.

> "It is an incentive to the continuation of the work".
>
> "Visits to schools provide direct contact with reality and enable observation of the work of the students".
>
> "It is very important to be there as an observer and to become aware of the affectionate relationship there is between students and teacher".
>
> "It helps us to overcome some problems and to renew strategies".
>
> "The visits to schools enable us to observe the students and their imaginative and creative ways of exploring certain programmes".

However, eight teachers, when discussing the exchange of experiences referred to the following aspects as negative : few schools visited, deficient planning of the visits. little exchange of experiences. One teacher wrote "the interchange of views is not always easy, because sometimes we always give and we do not receive anything". Some teachers in informal conversations expressed some disagreement related to the visits as a Primary school teachers stated:

> "... the fact that each school has its own problems and talk about them may affect the exchange of experience sessions, so we lose time" (field notes 15/3/88).

7.3.2.2. Technical- Pedagogical seminars

Seventeen teachers considered these seminars to be very important for their training, stating that they were "useful, interesting, positive". One of the teachers said "It is motivation for more creative work, better execution and more direction towards the students' interests". Nine teachers considered that the number of seminars was not enough and mentioned the little spare time they had to practice the technical issues.

> "It was insufficient for those programmes with which I wanted to work, and some of them were a little tiring. they should be more frequent and short. (Primary school teacher)

7.3.2.3. Pedagogical exploration of certain programmes

Seventeen teachers considered these sessions very positive as they "make learning livelier". The pedagogical exploration of computer programmes enabled the evaluation of their potentialities for more creative teaching. "It is interesting to notice that students become more devoted to activities where the computer has a role" (said a teacher from Primary School). "The pedagogical exploration of such programmes as Data Base and LOGO is very positive, they are fundamental and very useful; it is necessary to reflect on the activities accomplished and those still to take place with the students". "This sort of work is fundamental. It is a priority to reflect on the activities to propose for students which will enable them to develop their skills".

The insufficiency of these sorts of sessions was referred to as a negative point by seven teachers.

A teacher explained that at this stage he considered the echnical issues as a priority, adding that "this does not mean hat at a later stage I will not consider the pedagogical training more important".

As during these seminars teachers had the opportunity to ear about experiences other teachers had already had, some eachers considered the exchange of experiences also an opportuity for pedagogical exploration. For instance, a teacher said "I onsider pedagogical exploration based on the exchange of experinces to be most important".

Later on, teachers were asked (annex C) about their evaluaion of the different training periods during the whole school ear, regarding the use of the computer as an instrument to upport the students' projects. Two teachers didn't respond to the whole of this part of the questionnaire. So the total here is 20.

In table T we can see that the technical seminars were cited by teachers (18) as having had an important role , followed by the direct support of the training teachers (14), and the seminars of pedagogical exploration of programmes (13). The exchange of experiences had 12 "important contribution" responses and the seminars of pedagogical discussion had 11. Half of the teachers considered the "project work" experienced in the first phase of the programme as "important" and the other half as a "moderate" contribution. The visits to schools had a "moderate" contribution for 14 teachers and were "important" to 4 teachers. One response in the items " exchange of experiences" and " the visits to schools" was a "null" contribution.

Table T: Contribution of the different periods of the programme to the use of the computer as a pedagogical instrument.

Periods of the Programme	Teachers' responses			
	Import.	Moderate contributions	Null	Do not know
Project work	10	10	-	-
Exchange of experiences	12	5	1	2
Visit to schools	4	14	1	1
Technical seminars	18	2	-	-
Direct support	14	6	-	-
Seminars of pedagogical exploration of programmes	13	5	-	2
Seminars of discussion of pedagogical aspects related to the use of computers	11	8	-	1
LOGO in Primary school	7	5	-	8

Note: Two teachers did not respond to this part of the questionnaire.

Teachers were also asked to comment on the length of these training times. Three teachers expressed the opinion that the whole programme was a short one, as one teacher said: "It was a pity to have only a Thursday each week", (it was the day of the week chosen for the course sessions).

Four teachers expressed the opinion that there should be a larger number of seminars of pedagogical exploration of programmes, and three teachers had a similar opinion about the technical seminars.

Seven teachers referred to the direct support as a very important part of the programme and thought that the amount was not sufficient, since sometimes, when they had some technical doubts, the development of the work was delayed by the absence of the teacher educators.

Two teachers said that the frequencies of the exchange of experiences was too much, because "we had to listen to what all the other people was doing, and sometimes it was a little boring".

Three teachers would have liked to have had more reflective moments about what they were doing with students. One teacher said:

> "In the beginning of this work it seemed to me that there should be more technical training, instead of for instance the project work developed in the first school period, but now I recognise that it was better so. However I say that we should have had more technical training, but we only had one Thursday in the week ".

Teachers' opinions about the different components of the programme was also analysed through their answers during the first interview. The analysis of the teachers' answers to the seventh question of this interview showed the parts of the programme to which teachers gave most importance. It should be remembered that from the nineteen teachers interviewed only seventeen cited explicitly some influence, saying what parts of the training programme were related to these influences. These are displayed in the following table:

able U : Emphases given by the 17 teachers who answered 'yes', o parts of the training programme.

Parts of the Programme	Frequencies
Exchange of experiences, discussion and reflection on common pedagogical issues	9
Group work preparing materials	8
Learning about computers	6
Practice work with students	2
Direct support of the teacher educators	1

The exchange of experiences, discussion and reflection on common pedagogical issues, as well as group work among teachers preparing materials were the parts of the teacher training programme most valued by teachers, followed by computer knowledge acquisition.

> "I didn't know anything about computers, and everything was new for me. Indeed many things have changed. We always stuck to the syllabus contents, now we may change its sequence in order to use the computer potentialities. The possibility of work with my colleagues, preparing materials together has been a very good experience for me. I think that relationships among people are very important, and indeed I found a very good relation among teachers of our school as well as with the other schools involved in this project. We supported each other and around this work we could find a good ambiance" (Ana, Mathematics teacher, first interview)

> "...I have the impression that if I had worked alone I would have lost a certain enthusiasm, perhaps I would have given up, ... the only thing bad for me, since working in the MINERVA project, has been a little hesitation regarding the machines,...all these buttons, plugs and so on, scare me" (Visual Arts teacher, first interview).

"...As you know I am the only English Language teacher in my school involved in the MINERVA project, and I already have worked on other things, but never like this. Concerning the work in groups with my colleagues it has been very enriching, in spite of the fact that they are from other areas. It is good to known that we are not alone, and we can support each other." (English Language teacher).

Concerning knowledge acquisition about computers six teach- rs expressed this aspect as one of the most important during the programme. For instance:

"...I have learnt about computers and when I look back I see a great difference from the beginning. (Susana, mathematics teacher, first interview).

7.3.3. Global discussion

Teachers after this year of training experience concerning the new subject of introducing computers in educational prac- tices, most valued the team work and the acquisition of technical knowledge as well as how to explore different software in con- crete students activities. This seems natural, as it was an unknown subject to them, bringing a certain insecurity related to their computer activities with students, and they seemed to want to know different possibilities for using new strategies in teaching. Teachers showed the need for support over the whole school year. This was also found by Cox and Rhodes, who noted that this kind of training was not easily available to a large number of teachers. The complexity of teacher education for teachers that are expected to use computers in schools (CERI document 1990) is mainly related to the broad set of subjects which should be included (Dubuc, 1988, Woodhouse and Jones, 988). While teachers in this study gave great importance to echnical aspects of their training, they also considered as very mportant the team work sessions where they developed materials or the students, providing discussions among them. These compo- ents were valued by teachers, as they provided the sharing of xperiences and ideas and the incentive to go further, since the eachers did not feel alone in their insecurities, and col- leagues' work gave them new ideas.

In spite of the first interviews having taken place only a few months later, teachers' answers seemed to reveal a difference from the beginning. During the interview teachers most valued the exchange of experiences, discussion and reflection on common pedagogical issues raised by the introduction of computers in their practices. At this time teachers did not give the importance to the technical training as they did in the beginning. There could be several reasons for this: teachers felt more confortable concerning knowledge about computers, and teachers had had time to view things in a different way, time to think and to understand their training experiences in a different way; or that most of the teachers chosen for the interview were teachers who, by chance, were more sensitive to these components of the programme.

CHAPTER 8

REVIEW OF THE RESULTS, LIMITATIONS AND IMPLICATIONS

8.1. SUMMARY OF THE AIMS AND FINDINGS OF THE STUDY

In this research I designed an in-service teacher training programme for teachers involved with computers in educational environments, and I studied its effects on teachers' attitudes towards computers in education, teachers' practices concerning teaching and learning as well as on teachers' professional development. It was also my intention to gain insights in order to allow the introduction of further improvements in future in-service courses.

The main findings of the study were:

1. Teachers were strongly influenced in their views about computers by the software used during the programme, as well as by the activities they developed during their own learning.
2. Teachers showed positive attitudes regarding the use of computers in education, including students' motivation, development of creativity , autonomy, and reasoning skills.
3. There were many differences among teachers' attitudes and practices during these two years, regarding the work they decided to develop using computers. These differences occurred both between teachers, and over time, in the views of individual teachers.
4. There was a relation between teachers' views about mathematics curricula (hierarchy and boundary of contents) and the level of students' participation allowed in learning activities.

5. Teachers identified new professional needs during the programme, mostly through the work that they carried out with students.
6. Concerning their professional developemnt teachers showed that they valued as important working in groups sharing experiences and ideas with their colleagues.

More detail is given in sections 8.3 to 8.5 where each finding is related to literature.

8.2. AIMS OF THE STUDY

The research was carried out in the context of the MINERVA project, which aims to introduce computers in Portuguese schools. This context provided the opportunity to bring together teachers from different school levels (primary and preparatory; 6 to 12 year old students), coming from different schools. Teachers involved in this study were not chosen by me, but they came to attend the programme as they were volunteers for the MINERVA project in their schools. They had four or five hours free of classroom work, and it was expected that they would begin to work in their schools using computers in educational activities. These teachers were working on the basis of a common project, the MINERVA, but they also had links to the schools to which they belonged. Nevertheless the teachers were free to develop the activities that they preferred with their students, depending more on this matter on the Node of a Higher School of Education or a University (the institutions in charge of their training) rather than on the administration of their schools.

In these conditions it was my intention to develop a teacher training programme that could provide links to teachers' practices in real educational contexts, and not to separate the training from their work with students. Moreover, it was my concern to exploit the ongoing experiences of the teachers for the development of the programme, drawing on their opinions concerning the projects they were developing with students, their difficulties in accomplishing them, and their needs to extend projects.

One of the main goals of the in-service programme of this research was leading teachers to adopt an open teaching approach, where students' learning could be seen as a personal construction with the teacher as facilitator of this process. The use of computers as a pedagogical tool in schools, was thought to be an opportunity for teachers to re-think both students' and teachers' role in the learning process, since they would have to learn a new subject (computers), and they would have to fit computers into their pedagogical practices. Three themes, active learning, computers in education, and teacher development were emphasised in this study, and reviewed in the literature.

Several aspects of the impact of the training programme on teachers - the main goal of this study - were becoming clear to me during its development in three main issues:

1) Teachers' attitudes towards the use of computers in both curricular and extracurricular activities;

2) Teachers' attitudes concerning the teaching/learning

rocess; and

3) Teachers' professional development.

The findings related to these three aspects which were studied in depth in chapter 5, 6, and 7, will be the subject of the next three sections.

8.3. TEACHERS' ATTITUDES TOWARDS THE USE OF COMPUTERS IN BOTH CURRICULAR AND EXTRACURRICULAR ACTIVITIES.

This issue was examined from the beginning of the teacher training programme until the end of the second year of field work of this study, in order to gain understanding of this aspect through the development of the course as well as related to the work that teachers were implementing with students. In spite of the fact that all the teachers were demonstrated to have a positive attitude concerning computers in education, from the beginning, they developed their understanding about the potentialities of this pedagogical tool, especially after the experiences which they were carrying out in their schools. This previous positive attitude towards computers by the teachers of this study is not very common. O'Shea and Self (1983) state that there is the idea that the computer's role in education can be to simulate conventional teaching activities. My experience suggests that this attitude and the feeling that computers can be a poor substitute for teachers is common among Portuguese teachers, at the time when this study began. The teachers in this study had as a starting point a different attitude, which explains why they offered to be volunteers to work in the MINERVA project.

One of the aspects most referred to by teachers over the whole period of the field work of this study, was students' motivation towards school and learning, and the role of computer activities in increasing this motivation. The teachers related the reasons for this increased motivation saying that "students have the opportunity of developing their own ideas", "students feel success and pleasure with computer project outcomes", "it is a challenge for students", "autonomous and power feelings", and other reasons such as computers are a novelty and are not connected by students with traditional forms of classroom work. Adams (1982) found that one of the major problems of teachers was student motivation and another was the impact of instruction on students. From the time that teachers began to work with students using computers they also focused on the effects of computers on the development of skills, such as creativity, autonomy, reasoning, working in a group; the mathematics teachers later mentioned especially problem solving and investigative work, and work projects. One of the educational advantages for the use of computers with students is to enable them to explore their own intuitive knowledge, and develop creativity (O'Shea and Self, 1983), and they are used to support the teaching of mathematics by introducing new styles of teaching and learning (Ball, 1988). As it is pointed out in the CERI document (1986), there are those who advocate that IT develops abstract thinking, creativity and communication skills, as well as the ability to work in a group; other people give emphasis to knowledge acquisition useful for professional life. The great majority of the teachers involved on this study emphasised the former rather than knowledge acquisition, through their work with computers. An explanation of why teachers viewed computers as having these sorts of educational benefits for students, might be that teachers were free to chose the kind of activities to implement, although they were influenced by the kind of software approached during the course, as well as the kind of activities which were suggested during the training sessions. Since in Portuguese schools, computers were still an innovation when this study began, these teachers did not have much prior knowledge about this subject. The software programs they learnt during the course and the way they learnt them, formed a reference for the work they implemented with students. Nevertheless teachers showed differences in the places they chose to work (classroom and computer club), as well as in the kinds of activities developed (related to subject areas, extracurricular work or projects). Also the work project which they developed in the first part of the programme seemed to contribute to the fact that some of these teachers wanted to experiment with a work project with their students, which is not usual in Portuguese schools. The opinions expressed about computers in education were therefore influenced by the teacher training programme, which also had effects on the activities they chose to implement, and on their views about the educational potentialities of computers. As Rogers (1992) says adult learning arises from their own experiences and it can take several forms of increasing their knowing, thinking, feeling and doing, according to each personality and prior history.

8.4. TEACHERS' ATTITUDES CONCERNING THE TEACHING/LEARNING PROCESS

This aspect was studied in a deeper way with the mathematics teachers involved in this study. Only six of the eight mathematics teachers chose to work with computers within the classroom, however all of them approached curricular learning with students, even if in the computer club.

Teachers described the influence of the teacher training programme, mentioning "more student participation", "altering the sequence of mathematics content", and "the need to think about new strategies for students learning". Diversified activities within the classroom, problem solving and students' discussion were strategies used by these teachers when they used computers in mathematics classes. In the computer club in extracurricular time, teachers chose different kinds of activities: project work, collaboration in school activities, and to extend the approach to mathematics topics used in mathematics classes.

The study and the analysis of all the data gathered (see chapter 6), provided a categorisation of the eight mathematics teachers into three categories: teachers who did not introduce computer activities within the classroom; teachers who introduced computers within the classroom, developing a teacher centred style and concerned with the boundary of mathematics content; and teachers who developed more independent work, not being so concerned with the sequence and with the hierarchy of content. Bernstein's theory concerning curricula and pedagogy relates these two aspects, considering that when teachers have a great degree of control and students are viewed as "ignorant, with little status and few rights" (p. 98, o.c.), the various content taught is strongly hierarchical and ritualised, without respect for students' pace in the learning process. In fact this study showed that teachers who revealed a greater concern with the hierarchy of mathematics topics, had a more teacher centred attitude, providing less student participation, and little respect for each students' pace in the development of the classroom activities. However one of the findings of this study was to realise that for these teachers it was easier to provide for progressive student autonomy by means of group work and sometimes discussion among them, than to break the boundary of mathematics content. This fact explains why some of these teachers worked with computers in clubs fostering greater student autonomy where the pressure of the mathematics curricula did not exist, and also explains why two teachers refused to work with computers within the classroom. Teachers in the first and second categories needed to feel in control of all the classroom work, maintaining the sequence of subjects in order. Even the three teachers of the second category, when they saw computer activities were being developed at different paces, felt the need to "give lessons" for all the class in order to "provide a systematisation of the topics, for instance with proportionality, after work with the spreadsheet" (Carla). All teachers recognised that computers are powerful tools to attain educational objectives which they thought to be important (see 8.2.). Some of them implemented problem solving and group work, and promoted some student discussion, although this was overcome by the need to teach each mathematics topic separately. The two teachers (last category) who promoted independent work, with discovery and inquiry activities, felt at ease handling the mathematics curriculum, and did not seem worried by the fact that students were in different phases of attainment of their tasks.

8.5. TEACHERS' PROFESSIONAL DEVELOPMENT

I was interested in studying teachers' professional development from the point of view of teachers themselves in order to gain insight about their awareness concerning the effects of the course and their work with students on their own development. Also it was important to know teachers' opinions about the different components of the training programme and how they valued them concerning their improvement as professionals.

Erault (1982) states that "teachers may not be able to state what they learned" (p. 6, o.c.). This issue was directly approached with teachers, at the end of the programme by means of a questionnaire, and later on with a semi-structured interview (see chapter 7). Due to the closed nature of the questionnaire, teachers only had to choose between "high", "moderate", "low" contributions, and they also could choose "I don't know" as an answer. The teachers' responses to this questionnaire showed a positive attitude towards the training programme, considering their improvement, since almost all the responses pointed out "high" and "moderate" contributions in all the items.

Later, during the interview an open question was asked in order to leave the teachers free to approach the aspects which they thought had been improved with the work developed so far.

Some teachers recognised that all the work developed during the year of attendance at the programme had allowed them to put into practice aspects that they already considered as important concerning the teaching/learning process, but which they thought to be impossible to put into practice, such as enhancing "students' autonomy", "to respect students' pace", and "students' engagement with school activities". Also mentioned by teachers was the increase of their confidence within the classroom when they developed independent work with students.

Other teachers considered that the programme helped them to become aware of the students' role in the learning process such as the possibility for students to be autonomous, and the importance of students' motivation. These teachers referred to their intention to act in a different way within a classroom context, mentioning the desire to change their practices looking for new strategies and promoting problem solving activities with students.

A deeper analysis of the teachers' views about their own development was carried out during the second year of the field work. At that time the programme was over but in fact they continued to work with students, having some support from a teacher educator, and they met together in order to discuss ideas and share experiences.

These teachers showed that they recognised a certain change in their methods of teaching, mainly related to problem solving, group work, independent work and they also recognised that they engaged more easily with their students in mathematics activities. Also some of these teachers become aware of student assessment issues, mentioning the need to articulate student assessment with the new methods of work.

As quoted earlier on page 53, Rogers (1992) states that adults learning arises from their own experiences and depends on prior histories. So different people developed in different ways. Teachers in this study showed that they recognised some improvement as professionals but this occurred at different levels: the level of their ideas and the level of their practices. Some of them belonged to both, as they were able to put into practice some ideas, and they also became aware of others. They showed that they were conscious of an increase of awareness towards some aspects of students' learning aspects, a will to experiment with new strategies within the classroom, where students could be more autonomous and engaged, and some of them understood that it was possible to act with students according to pedagogical ideas which they thought to be not possible.

Erault (1982) considers that awareness of ideas about teaching does not mean that teachers are able to use them in the classroom. Day (1981) also found that teachers when confronted with their practices and with later discussions concerning the relationship between their ideologies and their practices, were more able to identify problems. This is an important starting point to begin a process of change, since teachers are confronted with their need to solve those concrete problems. The increase of teachers' awareness of pedagogical issues with the consequence of the teachers' will to experiment with new strategies with students and to develop their understanding about them, is what some authors call "needs identification", (e.g. Day, 1981, Nixon, 1989, and Hopkins, 1989). The identification of these problems or the need to be able to act in a different way are real needs that teachers faced. Nixon (1989) for instance considers that to assess ones own needs is an hard task that requires time and reflection and Hopkins (1989), Day (1981), and Kirk (1988) state that needs identification should be included in teacher training programmes, since this aspect is closed related to a "teacher' s awareness of a problem in practice and the commitment to explore ways of solving that problem" (Kirk, 1988, p. 48, o.c.).

Teachers in this study showed they had also developed their awareness towards aspects of students' learning, some of them mentioning the desire of experimenting with new ways of working.

During the second year, six of the eight mathematics teachers wanted to experiment by introducing computers to approach some mathematics topics using LOGO and Spreadsheets. New needs were being identified, demanding more support and opportunities to share experiences and to discuss issues raised by their experience.

A relationship was also found between the three categories of the mathematics teachers defined in chapter six and their opinions concerning their professional development. Teachers who developed more open tasks providing a more active role for their students in the development of classroom activities, mentioned as a major improvement the promotion of student discussion. They also stated no need to feel in control of the class as they did before. Teachers who introduced computer activities within the mathematics classroom, although worried with the boundary and sequences of mathematics topics and providing little autonomy for students to follow their own processes of learning, mentioned aspects of their development such as awareness of active role of students, students' motivation, team work, and problem solving. Teachers who did not introduce computers within the classroom, only referred to the fact that they had learnt and experimented with new things, and the teacher of this category who developed project work in a computer club also mentioned her awareness of the importance of student motivation.

During the development of the programme teachers were asked to give their opinion about the different training experiences they were going through.

At the beginning teachers showed they valued the technical training, giving emphasis to the hand-on experiences, both during the courses and self training. However they always referred to the pedagogical as important. When teachers' insecurity towards computers was becoming weaker, they increased their references to the team work sessions, mentioning the development of materials, sharing of experiences, and the reflection upon common issues raised by the work they were implementing with their students. Teachers showed a need for continuous support throughout the school year, and also the mathematics teachers expressed this need during the following year. This aspect is referred to by several authors (e.g. Woodhouse and Jones, 1988, Cox and Rhodes, 1989), when teachers are learning about computers in order to integrate them within their classroom.

.6. LIMITATIONS OF THE STUDY

This study has some limitations which I will discuss in this section.

I. One of the major limitations was the fact of my own involvement in the MINERVA project, which may have influenced both mine and teachers' opinions. Perhaps with other external researchers the results could be different.

II. The lack of opportunity to do much observation in schools implied that the main sources of data were teachers' perceptions and not teachers' actions.

III. Another aspect was that, as teachers came together in a common Node of the MINERVA project, this study was concerned mainly with teachers as individuals rather than with teachers belonging to a specific school context. So, the influence on teachers of the dynamic of the school where they worked was not taken into consideration in this study.

IV. During the two years of the field work of this research, teachers were not "closed"; they probably had contacts with other people. Then, teachers' views about computers in education could also be influenced by factors outside those they experienced during the programme.

V. Another aspect is the fact that teacher development is a long process and two years could not be enough to understand the effects of the programme on their professional views and practices.

VI. Finally I see a limitation of this study, in its generalisation for other in-service teachers training programmes, the fact that these teachers had free time from classroom work to attend the programme, as well to develop extracurricular work with students. During normal conditions, most teacher training programmes have to be developed alongside full time school work.

8.7. IMPLICATIONS

The implications of this study will be discussed in two sections: 1) implications for further research, and 2) the implications for future in-service teacher training programmes

8.7.1. Implications for further research

This study can provide an useful framework for future design and evaluation of in-service teacher programmes to be developed in Portugal, even out of the context of the use of computers in education. It is important to investigate the experiences that teachers undergo during training programmes which provide continuous support, incorporating times and spaces for them to meet together, especially those programmes approaching innovative methods and subjects. However it will be important to study these aspects together with a deep study of the social contexts of each school where teachers work and to incorporate more study of teachers' classroom implementations.

Also it would be important to develop research in other INSET methods, as well as over a longer time in order to study the teacher development issue across more years that those of this study. The relation of the impact of INSET on teachers with their previous personal history, can be a way to gain understanding about the differences in teachers' attitudes after the same course.

8.7.2. Implications for future in-service programmes

Computers being a new subject for the teachers of this study, the software used as well as the activities developed during the programme were a reference for the activities chosen by teachers when they developed work with their students. Pinner (1985) claims that INSET can often help teachers to develop styles of working with students, because they realise that if they themselves benefited from practical group activity and discussion during the courses, then for students this can also be good. Other authors (e.g. Hoyles, Noss and Sutherland, 1988) advocate this aspect, claiming that teachers tend to behave towards their students using the same techniques and methods of using computers which they experienced during the training course, using computers. This issue of the methods used on courses for teachers should be a concern for those who are in charge of designing and implementing teacher training programmes with the objective of teacher development involving some change in teachers' style.

Lewis (1991) claims that teachers' learning through personal research which includes personal ways of acquiring knowledge and skills leads to the development of "a sense of owning" (p. 2). This attitude towards learning, which was experienced by teachers in this study can also be a way of encouraging teachers to promote a more independent teaching/learning method with their students.

When teachers are faced with a new tool to use in working with students, or are involved in innovative programmes, they feel insecure (Fullan, 1982; Dubuc, 1988); this study showed how this insecurity can be reduced by group work where they could develop materials, share experiences and reflect upon them. These aspects were valued by the teachers in this study. Several authors (e.g. Shon, 1987, Day, 1987, Brown, 1988, Hoyles, 1989 and Rudduck, 1991) also mention the importance of reflection and critical thinking about their own practices. This reflection can be responsible for the emergence of new needs which should be included in teacher training programmes, providing new experiences, new reflections, in a process of teacher development (e.g. Day, 1981, Easen, 1987, and Bell, 1991). To link the training with real educational problems that teachers are finding through their practice implies organising in-service teacher training programmes in such a way that teachers can be supported during an extending period. This support also means finding common spaces and timing in order that teachers can meet together. In the case of this study teachers needed more than one year of support. Perhaps with some teachers, further sessions should be maintained until they feel able to be autonomous in their own process of professional development.

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ANNEX PS: PILOT STUDY

This study was developed in cooperation with João Pedro Ponte of Faculty of Sciences of the University of Lisbon. It was presented at PME XI in Canada, 1987.

PROJECT WORK WITH TEACHERS INVOLVED IN A PROGRAM FOR THE USE OF COMPUTERS IN EDUCATION

Maria Cecília Monteiro
Escola Superior de Educação
de Lisboa

João Ponte
Universidade de Lisboa

This research describes the evaluation of a teacher training program set up to implement the use of computers as a support for project work. The teachers, who entered in the program mainly with the motivation of learning how to use computers, recognized changes in their attitudes and pedagogical practices.

The national Project Minerva was established in 1985 to promote the introduction of computers in Portuguese elementary, middle and secondary schools. This project pretends to contribute to the technological updating of school curricula and methods, and has a concern for pedagogical transformation. Universities and Superior Schools of Education are charged with the training of teachers, curriculum development and its evaluation, as well as with the necessary support to the work carried out at the schools.

Teachers of several disciplines are involved in this project. However, many of those who are most interested and become leaders within the schools are mathematics teachers. So far, most of work involving students has been realized through extra-curricular activities. Some of the teachers tried to use the computer in the classroom, but this has been difficult given the scarcity of appropriate software and insufficient quantity of existing hardware.

To use the computer in the classroom does not imply necessarily a change of pedagogical attitudes, student/teacher relationships, and learning processes. The computer can just be used to reinforce a tradicional style of teaching. In project work, students have the possibility to participate in the choice of the problems that they want to deal with and to define the corresponding strategies, methods, and forms of presentation of the results. This pedagogical approach, which remotes to Dewey and Kilpatrick, intends to assign the students a responsible and independent role in their own learning process. Dewey (1959) wanted to give a livelier content to education, in opposition to teaching just from listening and from books, by following the principles of motivation, dedication and organized work in order to achieve a learning goal. In his views about the use of computers in education, Papert (1980) also stresses the importance of the deep involvement of the students in the learning process through their personnal project.

Many contemporary teachers are in a way or another sensitive to these proposals. However, project work is not easy to implement in a long term basis, and most for the actual activities carried out in todays schools still draw from the traditions of straightforward transmission of ready made knowledge, memorization, and passive learning. To make teachers aware of the possibilities, difficulties, and conditions of sucess of project work and to invite them to start using this methodology with their students, it seems reasonable to involve them in a set of activities of a similiar format.

THE STUDY

This research intended to evaluate the effects of a training program in project work on teachers, attitudes concerning this kind of pedagogical strategy and to evaluate its effectiveness in developing their ability to conduct students in project work oriented activities, using computers. This evaluation was also intendend to provide informa tion to improve the design of the training program.

Specific objectives of this program on project work were to make teachers: (a) develop skills of organisation and cooperation in group work, (b) develop research skills and the ability to organize and present information, (c) be aware of different aspects of verbal and nonverbal communication, (d) view knowledge in a interdisciplinary perspective, (e) recognize the importance of intrinsic motivation, and (f) stimulate their iniciative and selfconfidence.

THE PROGRAM

Involved in this study were 22 teachers, all participants in the Project Minerva. Of these, 13 were teachers of mathematics and 7 teachers of other subjects.

The training program was developd in two phases. The first phase consisted of a four day workshop which main objective was to give an overview of project work methodology. The second phase concerned the implementation and evaluation of project activities in the schools.

In the first phase, a general problem was selected in big group discussion and then subdivided in smaller questions which were taken on by different subgroups. Each subgroup selected its own methodological strategies, including labor organization, data collection methods, data analysis, and forms of presentation of the results. After the presentation of each subgroup there was a discussion period in which the different contribuitions were confronted with the general problem initially defined. Finally, there was a general discussion to evaluate all the activity.

The second phase, included the introduction to the use of computer tools such as spreadsheets, data bases, word processing, drawing applications, an initiation to the LOGO language, and monthly seminars for discussing pedagogical themes related to the use of computers and project work and for exchange of experiences and reflection on the ongoing activities in the schools.

EVALUATION

There were two main periods of evaluation: the first took place at the end of the initial project work workschop. Since this activity represented for most of the teachers a first formal contact with this methodology, it seemed important to evaluate it just after the end of the workshop.

There was some discussion to decide if the problem to be selected should concern or not directly computers. The teachers decided that the computer ought to be regarded as just an instrument among others and picked up as their question "what can be done to improve the school?". This question was taken with enthusiasm by the participants, who assumed their role in the study of the subquestion in which it was subsequently divided. Some teachers felt inconfortable in doing actual field work, but the pressures of the needs of the group overcome this difficulty. Most of the final presentations were quite creative and original. In a short Likert type questionnaire they reported to have enjoyed the workshop and some indicated to have aquired new pedagogical perspectives to use in actual practice.

In the second evaluation, carried out six months after the initial workshop, the teachers were asked to respond to a more detailed questionnaire. One group of questions concerned the self-evaluation of change of attitudes by the teachers themselves. Another group concerned the different activities undertaken. Three other open question asked for comments on the difficulties and the potencial of project work. Twenty teachers answered this questionnaire.

The responses to the first group of questions are summarized in Table 1.

A global analysis of the responses to the questionnaire showed that in this phase of the work most of the teachers considered that the activities carried out contributed to improve, either highly or moderately, the qualitity of their work in the mentioned areas. For the whole set of questions, 39% of the responses indicated a high contribution, 46% a moderate contribution, 12% a low contribution, and 3% were "don't know" responses. The item that had most

TABLE 1

Contribution of the teaching training program to specific areas-teachers' responses

	Contributions High	Contributions Moderate	Contributions Low	Don't Know
A. Development of an attitude of permanet learning	95%	5%	-	-
B. Development of capacities of organization and technics of group work	15%	60%	25%	-
C. Awareness of the importance of the affective aspects in the learning process	25%	45%	20%	10%
D. To view knowledge in an interdisciplinary way	40%	40%	20%	-
E. Awareness of the problems of communication in the school context	35%	60%	5%	-
F. Development of new perspectives concerning the role of the teacher in the school	40%	55%	5%	-
G. Development of a new relationship with students	40%	40%	20%	-
H. Development of the ability to stimulate and to support the project of the students	35%	60%	-	5%
I. Development of a more positive perception of their function as educatores	30%	50%	10%	10%

positive responses concerned the development of an attitude of permanent learning. Following were the itens D, F, and G. The items B,E,H and I received mostly moderate responses. The answers of the mathematics teachers and of the teachers of other topics were similar for all items, except for items E, G and I, in which mathematics teachers were eager than the others in recognizing a high contribution of the training program.

A second set of question concerned the specific contributions of the several moments of the teacher training program. Some of this moments had a pedagogical emphasis and others concerned the use of specific computer tools. The most valued of the pedagogical activities was the initial workshop (63% high). For the remaining, the teachers tended to rate higher the activities that were mostly related to their actual experiences. The sessions concerning the specific computer tools were in general quite highly rated (all with more than 42% high).

At last, in open questions, we asked for the opinion of the teachers about the difficulties related to project work as well as for suggestions for the improvement of the program. Most of the teachers indicated several difficulties that they face in trying to use the computer as a support for project work in their schools. A content analysis of the 51 answers indicated that the scarcity of available time and the insufficience of material conditions, namely, computers and appropriate working spaces, were mostly refered (29%). Pressures from programs and the negative attitudes of their colleagues were also mentioned several times (10%and 18% of the answers, respectively).

Concerning the role that should be given to the reflection on the pedagogical aspects of the use of computers in education, 89% of the teachers agreed that this aspect should continue to have a strong emphasis in the program. However, they suggested a shift towards more practical issues and more exchange of experiences.

The projects developed in the schools by these teachers may be grouped in two kinds: projects with teachers and projects with students. In the first case, were offered courses related to the use of computer tools, such as drawing applications, word processing, and LOGO. There were also sessions for all school to show the educational potencial of computers. In the second case, there were experiences with LOGO and other computer tools in extra-curricular activities, as well as one experience on teaching Geometry in a 5th grade classroom. Projects such as the school journal and other interdisciplinary activities were also implemented in most of the schools.

A more detailed evaluation of all these projects will be performed on the end schools year in order to improve the working methods and to divulge and extend this kind of activities to other schools.

CONCLUSIONS AND IMPLICATIONS

Overall, we tend to believe that this training program was quite succefull. It seemed to have a reasonable mix of "pedagogical" and "technical" components, which reiforced each other and promoted teachers willigness to change some of their attitudes and practices.

The introduction to the use of computer tools and LOGO constituted for most of the teachers the main motivation. The discussion of pedagogical themes was appreciated and the teachers recognized it as important for the acquision of skills in developing work projects with the computer in their schools. However, we feel that this pedagogical discussions should be more deeply rooted in teachers practical experiences.

It would be unreasonable to expect outstanding results in a rather limited period of time. The inservice training of teachers should be viewed as a long term process. Particularly in this case, the teachers need to learn many new things about a new medium, the computer. However, these teachers are becoming leaders in their schools by introducing the computer as an instrument of pedagogical change. These teachers will participate in the training of their colleagues. So, this involvement may rather be an important part of the training program next year.

REFERENCES

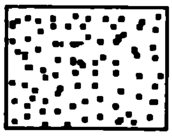
Dewey, J. (1959). Dewey on Education. New York: Teachers College Press.

Papert, S. (1980). Mindstorms. New York: Basic Books.

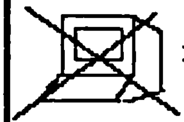
ANNEX P: POLYGONS WORKSHEETS

Annex P1: Polygons

1. Look at the picture. What is the name of the polygon?



2. Give instructions to the turtle to draw a polygon like this, and write them here:



2.1. Now according to the turtle movements, complete:

. The square has____ sides
. To draw each side the turtle gave____ steps
.The sides of the square________ all the same length

. The square has____ angles
. In each vertex the turtle turned ____ degrees
. All the angles of the square____ have the same amplitude

2.2. Using one of the following designations: oblique, parallel, perpendicular, complete:

Two consecutives sides of the square are ______ and two opposite sides are______

Information: The polygons whose sides and angles are geometrically equal are designated regular polygons.

Conclusion: The square is a parallelogram with all the sides and all the angles geometrically equal
The square is a regular polygon.

3. Write the following programmes and try them:

```
To Flag
FD 60
Repeat 3 [Rt 90 FD 20]
RT 90 BK 40
End

To Flags
CG Repeat 8 [flag RT 45]
End
```

3.1. Complete:
The following 8 polygons displayed in the screen are squares as:
____

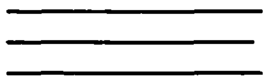
ANNEXES P2; P3

Annex P2: Polygons

1.1, 1.2, 2.1, 2.2, 2.3, are the same activities of the annex related to the square, but now for the rectangle.

3. Observe the picture and draw the procedure to draw the following picture, knowing that:

$\overline{AB} = 3 * \overline{BC}$

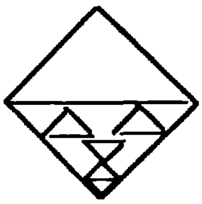


3.1 How many rectangles are represented in the picture?

Annex P3: Polygons

These activities are similiar to those for the square and the rectangle but now for the rhombus and the triangle

In respect to the triangle it was also asked to write the procedure of the following picture:



ANNEX R: RATIONAL NUMBERS WORKSHEETS

ANNEX R1

Annex R1: Rational Numbers

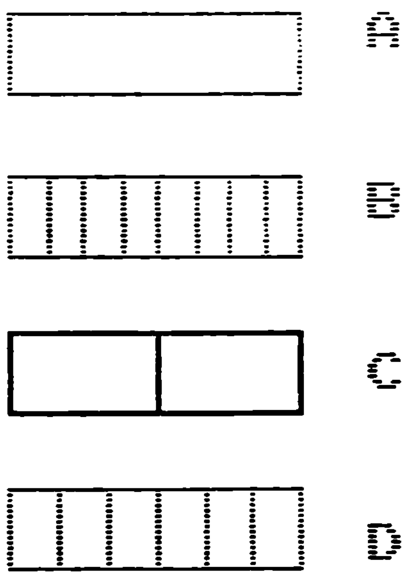
Using the LOGOWRITER, you can talk to the computer. Today I am not telling you what you have to do, it is your computer...

Read the instructions in the command zone, and answer its questions.

Look out! If you make a mistake...it will be angry with you!, But if you do all right... it will be happy with you!

1. In your work disk open the Directory \rational
2. Select the page rac1
3. With the command "fill" paint in the picture 1/2 in the rectangle A, 4/8 in the rectangle B, 3/6 in the rectangle D. What do you can concludeabout these fractions?

____



ANNEXES R2; R3;R4

Annex R2 : Rational Numbers

1. This activity is similiar to the annex R1, but now students should compare with the symbols > and < some fractions represented by a picture in the screen.

Note: The addition and subtraction of numbers represented fy fractions were apprroached in the same way.

Annex R3: Rational Numbers

1. Write a procedure to draw four circles with the same radius and with the following conditions:

In the first circle fill 1/2 of the picture
In the second circle fill 2/6 of the picture
In the third circle fill 1/3 of the picture
In the fourth circle fiil 2/4 of the picture

2. Did you find equivalent fractions?
Write them____________________

3. Write one more equivalent fraction for each of them.

____

Note : These activities are repeated for hexagon, and other polygons.

Annex R4 : Rational Numbers

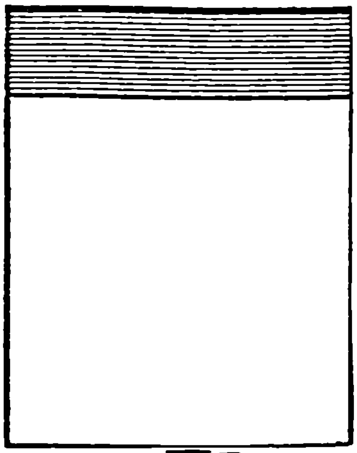
1. Choose a geometric figure and write a procedure to draw it and represent each of the following parts of it:

1.1 1/4 + 1/4
1.2 1/4 + 2/8
1.3 4/6 - 1/3
1.4 1 - 1/5

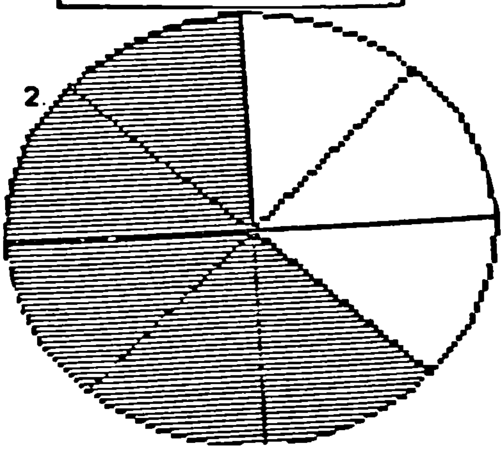
Note : There were other activities like the previous with numbers.

ANNEX R5

Annex R5: Rational Numbers

1. 

Sara is doing some wearing and she already did the part that is filled in the picture. During the week end she wove the quadruple.
Write the procedure and fill the part that she did in the week end.

2. 

Sara's family is a big family. She has four brothers: Hugo, Rui, Pedro and Marco.
The part that is painted in the picture represents the part that of the pudding eaten by her parents and the brothers except Pedro who ate 1/2 of the rest. Paint the part of the pudding eaten by Pedro.

Note: Other problems similiar to these were developed with LOGOWRITER

ANNEX S: SPREADSHEET WORKSHEETS

ANNEXES S1; S2

Annex S1. Spreadsheet

1. Let's start to guess messages

1.1 Load the SC3
Use the help 1

1.2 Open the file "Letter"

Use the helps 2, 3, 4 and 5

1.3 the computer sent you the following message

A11 - F19 - H11 - E10 - G17 - A12 - D12 - E10 - J8-
E10 - A16 - H11 - E10 - G50 - B38 - D12 - A16 -
D12- C9 - D18 - F19

Try to guess it, searching the content of each cell displayed on the screen.

Use the Hepls 1, 2, 3 and 4.

1.4 Clear the screen.

Use the help 9.

2. Now, you are going to send a message

2.1 Choose a code and write your message

Use the helps 3, 4, 5, 6, 7, and 8.

Save the code chosen by you and confirm to see if it is really saved.

Use the helps 10 and 11.

Note: The objective of these tasks was to provide a first approach to some technical aspects of the spreadsheet, and also to develop the understanding of row and column tables.

Annex S2. Spreadsheet: "Helps" /"Aids"

Some examples:

Help 4. Moving the cursor

To move the cursor between very distant cells, instead of using the movement commands (→), you can write " =" and the name of the choosen cell. For instance, if you write "< = R35 >", the cursor will jump to the cell R35.

Help 9. Clear the screen

1. Use the command **/Zap**
2. Choose the **Yes** option, and then press <enter>

Help 10. Save a file

1. Choose the name of your file.
2. Press **/Save** followed by the me of your file
3. Press <enter>.
Some options are displayed on the screen.
4. Choose the option **All**.

Help 14. Use algebric rules (formulas)

Sometimes the value of a cell depends on the value of other cell or cells. To fill it, write in this cell a rule, for instance:

The value of A5 is 3, and the value of E5 is 30. If the value of G5 is obtained by the multiplication of the previous two cells, in cell G5 you should write A5*E5, instead of 3*30.

So when you use a rule , it goes to the memory of the computer and stay there.

Help 20. Print a graph

1. Put the printer in the **on line** position
2. Press **F9**.

ANNEXES S3; S4; S5

Annex S3: Spreadsheet

Let's go to do a cake:

1. Organize in your spreadsheet the following data for an apple pie.

   4 eggs
   150g of sugar
   100g of butter
   250g of flour
   2 apples
   1 lemon
   2 spoons of jam

2. Suppose that Rita wants to use 8 eggs. Do the necessary replacements in the next column

Use the Helps 14, 15, and 16

3. Now, suppose that the initial quantities were adequate for a family with 6 persons, using different columns adapt them to 15 persons.

4. Multiply each of the initial values by 1.5. For how many persons are these quantities?

Use the Help 16.

5. Save your work

Use the He 10.

Annex S4: Spreadsheet

What is the rule?

1. Load the file SEQUENCES. Look at the first one.

2. Try to discovery the rule which enables you to write the members of the sequence and complete the empty space, using the rule you find.

3. Write all the terms until the end of the page (raw 20)

Use the Help 16

4. Observe the 2nd, 3th and 4th sequences

5. Try to discover the rule for each of them.

6. Write now the following terms as you did in 3.

7. Within the H and I columns write two sequences using a rule chosen by you.

Use the Helps 16 and 18

8. Save your work.

Annex SC5: Spreadsheet

Graphs ...and more graphs

1. The following table displays the minimum values of the temperature, in Lisbon, troughout a day:

HOURS	6	8	10	12	14	16	18
TEMP. ºC	7	11	12	15	17	16	14

2. Write these values in your spreadsheet

3. Graph nº1
Draw the bar graph

4. Graph nº2
Draw a cartesian graph (choose the **Line** option instead of the **Bar**)

Note: You can have 9 different graphs in the same spreadsheet. To give the number 2 to your graph after using **/View**, press *2.

5. Graph nº3
Draw the circle graph (choose the option **Pie**)

In this case is the circle graph meaningful?

Why?

Note: There are not helps related to the graphs, since students did the same activities where all the graph commands were explained step by step

ANNEX A

EVALUATION OF THE TEACHER TRAINING PROGRAMME

Questionnaire 1

During the first term you have been involved in a teacher training programme in order to support the work in your school, concerning the introduction of computers in education. To evaluate this programme for future improvements and for programming the next training activities, we would be very grateful if you would answer the following questionnaire. Please do not write your name. The questionnaire is anonymous.

1. Please mark a cross in the appropriate place:

Primary school teacher ___ Preparatory teacher ___

Mathematics teacher ___ Other subject ___

2. Of all the work developed in this first term which was the most important aspect for you? (Direct support, self training, team work, etc,)

3. Do you think that this kind of teacher training has been useful:

   3.1 To regard the computer as an educational resource?

   3.2 To change your expectations concerning the educational potential of the computer?

4. Do you consider that this work has given you new perspectives regarding your role as a teacher?

5. You will have attended workshops or teachers seminars. Please mention some aspects you consider should specifically be included in a teacher training programme for teachers involved with computers in education.

6. Please write the positive aspects and/or negative points you have found during the first phase of the work.

Negative points:

Positive points:

7. Please give some suggestions which you consider may help a teacher training programme for teachers involved in computers in educational activities.

ANNEX B

EVALUATION OF THE TEACHER TRAINING PROGRAMME

Questionnaire 2

During this period you have had the opportunity of participating in the second phase of a teacher training programme concerning the use of computers in Education. To evaluate this programme in order to provide the necessary improvements and to prepare the activities for the next stage, we would be very grateful if you would answer the following questionnaire.

Thank you for your collaboration. Do not write your name. This questionnaire is anonymous.

School level: Primary ___

Preparatory ___

Subject: ______________________

1. What were the negative and positive aspects of the training activities developed (visit to schools, exchange of experiences, technical-pedagogical seminars, pedagogical exploration of the programs)?

2. For you which were the activities you considered to be the most important?

3. Did the work developed in your school with the students meet your expectations?

4. Do you think that additional support is necessary for the introduction of the project activities with the students?

5. During the third period seminars are expected to take place concerning pedagogical issues which have emerged through the introduction of computers in schools. Please let us know which the themes you would like to look at.

ANNEX C

EVALUATION OF THE TEACHER TRAINING PROGRAMME

Questionnaire 3

We have been working in this node of the MINERVA project since September 1987. We have been interested in dealing with the computer as an instrument of "animaçao pedagógica*" of the school as well as a source of and support for activities and projects, giving the students new abilities and knowledge.

In this perspective the objective of this questionnaire is to gather information in order to evaluate the technical and pedagogical training received. Through this information we will be able to proceed with any necessary adjustments and improvements.

Your cooperation is appreciated. Please do not sign. The questionnaire is anonymous.

Primary school teacher ___

Preparatory school teacher ___ Subject _____________

---

* "Animaçao Pedagógica" is a Portuguese expression for the set of extracurricular activities involving teachers and students. In

this thesis it is also designated by " School Dynamisation".

1. In what ways do you think that the activities developed contribute to the improvement of the quality of your work in the following areas:

	High	Moderate	Low	I Don't know
Development of an attitude of permanent learning				
Awareness of the importance of intrinsic motivation in knowledge acquisition				
Development of the capacities of organisation and technics of team work				
To view knowledge in an interdisciplinary way				
Development of a more positive perception of your function as an educator				
Development of the capacity for research regarding the gathering, organisation and presentation of information				
Development of a new relationship with students				
Development of the ability to stimulate and support the students' projects				
Awareness of the problems of communication in the school context				
Development of new perspectives concerning the role of the teacher in the school				

2. How do you evaluate the contributions of each of the following training periods, regarding the use of the computer as an instrument of "animaçao pedagógica" and source and support of the students' projects.

	Important Contribut	Moderate Contribut	null Cont.	I did not participate
Project work				
Exchange of experience seminars				
Visits to schools				
Technical seminars				
Direct support				
Seminars on pedagogical exploration of programs				
Seminars on discussion of pedagogical aspects related to the use of the computer				
LOGO in Primary school				

3. Please comment on the frequency of these periods during the year.

4. As far as you are concerned, what is the main potential of the computer in school, mainly related to the work with students?

5. What are the major difficulties for a teacher in school who wants to use the computer as support for the implementation of activities and projects, both in curricular and extracurricular activities?

6. Other comments.

ANNEX D

FIRST WORK PROJECT INTERVIEW

Note: The methodology for this interview was as following: teachers think about the questions , individually, and then discuss with the group. Only after this team discussion, the interview was done, that means the researcher talked with the whole group about the interview questions or other issues raised by the interviewees.

1. How is your work proceeding?
2. Are you getting the best resources from each of you?
3. What are your major difficulties?
4. Are you following the previous plan of work?
5. Are you achieving your objectives?
6. Have you thought of changing anything taking into account time or other limitations ?

ANNEX E

SECOND WORK PROJECT INTERVIEW

Note: in this interview the methodology followed was the same as the one before. Some additional information was given, about the report to be presented in the final presentation.

1. Did you have find a good material to illustrate your chosen problem?
2. Do you think that you have formulated the problem well? Do you want to reformulate it?
3. How are you working with your group? Are there any problems within the group? Do you want to talk about this?
4. How are you aiming to present your work to the whole group?

Note: The material for the work project interviews was inspired by the documentation developed by the Higher School of Education of Stockholm (Sweden) and brought to Portugal in 1976).

ANNEX F

FIRST INTERVIEW

1. Why do you think that students enjoy working with the computer?

2. What are in your opinion, the main aspects that may be changed at school, with the introduction of computers in Education?

3. Are you interested in using the computer in curricular activities, in your school, one day?

4. Do you think that the computer in the classroom can change anything in curricular activities?

5. In your opinion, which is more important in working with computers, curricular or extracurricular activities? Why?

6. Do you think that school failure may be decreased with the introduction of computers in schools?

7. During the last year you have been developing a lot of work: work with students, attendance at teachers' workshops and seminars, exchange of experiences and ideas with colleagues. Do you think that all this work, in some way, has affected you in your conceptions of or attitudes to the teacher's role and the student learning process?

8. In your opinion, what is the ideal number of computers in school? And what future can you imagine for computers in schools?

ANNEX G

SECOND INTERVIEW

1. Do you think that you are using the same methods which you used before with students?

2. Please detail any changes?

3. In your opinion what is the main importance of computers in education?

4. Does the computer have a specific role in school, or is it just another resource?

5. Since you have been working with computers in the mathematics curriculum has this raised any students evaluation issues?

6. Do you reward your students for their work usually? Please specify.

ANNEX H

THIRD INTERVIEW

Note: This was a very open-ended interview, as it began with the same questions and all the others followed on according teachers' answers.

1. Could you build the picture of a mathematics classroom situation, imagining you had the computers you needed and did not have any kind of impediment.
2. And now could you build up the picture of a computer club situation, imagining you had the computers you needed and did not have any kind of impediment.
3. Did the computer work with the students help you to clarify your role as an educator and as a mathematics teacher?

ANNEX O

OBSERVATION OF A CLASS IN THE COMPUTER CLUB

Within the computer club there were five MSDOS computers and a big table in the centre.

Fourteen students were developing a project with LOGO WRITER. Dina, the teacher, decided to work only with half of the class. The other half would work in the next hour.

When the students came in, they went to their places and began to work.

The teacher discussed with a group of four girls working at the table, a text that they intended to write related to three scientists who had came from three different eras and who were supposed to meet together on a certain planet. The text would be illustrated with some drawings made in LOGOWRITER. Dina said that they should take the text to the Portuguese class in so that it could be corrected by the teacher who taught Portuguese language. Both the girls and the teacher discussed how to integrate the text and the drawing. During this discussion the students decided that the text would be written with dialogs. Then Dina suggested that they could write the text in different parts.

The Other three pupils were on the computer drawing the solar system. When the teacher came to these children, she told them to use the "shapes" of the LOGOWRITER in order to have the planets turn around the sun. While the teacher was working with this group the girls who were looking at the text continued their discussion.

Two students came in later, but they said good morning and they sat down near the computer and began working, continuing the work of the day before. They were making a butterfly, with several circles all tangent in a common point. They now had to do symmetrical drawing in order to make the two parts of the butterfly.

Another group was also working on a text of Copernio, Galileo, and Ptolomeu, and they were going to meet on an imaginary planet which they were going to create and to draw in LOGOWRITER.

Two students were working in the geocentric system.

The students who were drawing the solar system decided to begin to draw on a piece of paper a project and they discussed how to give commands to the turtle. The students who were drawing the butterfly discovered the way to draw the tentacles of the butterfly in LOGOWRITER, and discussed the colours, and how to program them.

The group of girls writing the text began to argue, because one of them said that everybody should give their opinion, not just some of them. The teacher came to calm things down. She suggested that they should take into consideration Sofia's opinion. Sofia was very upset in the corner of the classroom. When everything was sorted out they realised that it was too late to go on the computer that. The fifty minutes ended, then the students who were on the computer turned off the computers, covered them and went out.

Some complementary notes.

This was a preparatory school (1o-12 years old). The work environment showed that students were at their ease. Most of them were engaged in their projects, however on a few occasions some children seemed distracted. The teacher took part in the students' discussion without imposing her own opinion. She was not asked for help too often. She did not seem to be worried with maintaining discipline; sometimes the students got up and they went to see each others' work.

The projects which students were developing were integrated into the large school project "the trip through the time machine: the interplanetary trip". They had began to read a book with the same name, at the beginning of the school year. They had discussed it with the teacher and they had chosen to do these projects. Others students in the school were doing other tasks with other teachers. All this work was presented on 23 June, in a full day open to all schools which were working together in the node of the Minerva project, of the Higher School of Education of Lisbon.

ANNEX TT

PEDAGOGICAL SEMINARS

These seminars were the three discussion / pedagogical seminars of the third phase which were not explained in chapter three.

1. The role of the computer in the school computer club

This seminar had the objective of discussing and reflecting on the different perspectives of a computer club in a school, and the different kinds of use by students and teachers, as well as the stimulation fostered by this new organisation in schools .

It was decided to promote a simulation (role-play) among some volunteer teachers; four different computer clubs were described, their objectives, the people involved and the kind of work developed, the software most used, and other aspects like the attitudes of the teachers in the school, the kind of students and students motivation towards the club, etc.. The role play consisted of the following: A representative of an official department, who was in charge of introducing the computers to the schools all over the country, was going to talk with the coordinator of each school in order to evaluate what was going on, and what would be the best way of generalising this introduction of the new technologies in schools. So each of the delegates had to explain and defend his own perspective of what a computer club should be in a school.

As the teachers knew about this situation, because of their own experience and that of some of their colleagues in other schools, and since all the preparatory teachers' work centred around a computer club, it was easy to understand and to interpret this simulation. The delegate of the "Ministry of Education", had to ask some questions about the student's power in the club, the involvement of other teachers, what were the main objectives of the computer club, and other pedagogical issues.

Following this simulation, a general discussion took place.

2. The role of teachers in charge of stimulating computer activities in school

This session aimed to make teachers aware of the importance of the practice of teachers in charge of promoting activities with computers in schools for both students and teachers. The teachers were asked to write a sentence trying to define what should be these teachers' profiles. All the sentences were displayed on a wall in order to be seen by all the participants. The teacher educator who was chairing the seminar underlined the more frequent aspects focused on by teachers, in order to begin the discussion. Several teachers' interventions pointed out some real problems which teachers faced in their schools, such as the difficulty of involving their colleagues in work with computers, how to overcome impediments and obstacles from the school administration. Also pedagogical issues emerged mainly related to the use of computers in curricular activities, which was one of the main needs expressed by these teachers for later work.

3. LOGO in elementary schools

This seminar was mainly attended by the primary school teachers and mathematics teachers involved, and its objective was to promote discussion and reflection about the use of the LOGO language by students. Some texts of Papert, Boussuet and Jean Paul Blank were provided for the discussion. The discussion was developed focusing on different aspects of the utilisation of LOGO, and its importance in the development of students creativity, cognitive skills and in the students' learning of mathematical concepts. The classroom context for a real participation of students in the problem solving situations with LOGO was also discussed, as well as the teacher's role of providing the students with activities.

ANNEX MT

THE MATHEMATICS TEACHERS

This annex describes the eight mathematics teachers in detail. For each of them data was gathered by means of:

Three interviews;

Teachers' comments during the working sessions;

Transcripts of the observation of the teachers in both classroom and club situations;

Informal conversations; and

Materials developed by teachers for working with students.

As described in chapter six, teachers developed the materials together in order to support the students' work within the classroom. However they also prepared some of them alone, and the work that they carried out was not the same. As has been already explained, some teachers preferred to work more with the LOGO and others the spreadsheet. The six teachers who worked with computers to approach mathematics content had mathematics schedule four times a week but some of them only worked with the computer twice each week. Two of these teachers did not develop work within the mathematics classroom, only working in the computer club.

Paula

Paula had fifteen years of experience as a mathematics teacher. She had positive expectations regarding the effects of the computer on students' learning. At the end of the school year 87/88, she expressed the view that computer work can contribute to a decrease in school failure, since the students become "more interested and engaged and it can improve the students' preparation for the secondary level". She believed that the computer in the mathematics classroom could develop some students' skills such as reasoning, relating concepts, and integrating previous learning with new mathematics learning.

Paula and the other teachers made some worksheets which they named "aids", to explain some technical spreadsheet commands. However she felt the need to discuss at the beginning of the class some of these instructions for the whole class. The students were very noisy, and some of them did not pay attention. Also the students who were working without a computer were not concentrating very hard on their work. This fact seemed to disturb the teacher, who sometimes told them to be quiet. The students who were with the computers were very enthusiastic, and sometimes one of them asked for help from a colleague working with another computer. They helped each other and only rarely asked for the teacher's help. The computer was used twice a week and during the other two hours Paula provided the "consolidation of the concepts" (her words); she explained to the whole class the subjects, asking the students questions, as she said: "during this time I try to organise their knowledge". However most of the time she also worked with groups.

Paula preferred to work with LOGO rather than with the spreadsheet, so she spent a greater amount of time with LOGO. The work she developed with LOGO in the classroom was very structured: for instance she asked students to paint 1/2 of a rectangle, being the figure already drawn on the screen (see annexes R.1., R.2). In Geometry she used activities such as those of the annexes P.1, P.2, and P.3. However sometimes she gave some time to students developing free activities with LOGO in the last part of the class. The students drew some pictures using the several polygons that they had learnt.

During this year Paula developed extracurricular activities collaborating in some school projects with the two other colleagues also in the MINERVA project at this school. The projects developed were for instance "Mother's Day", "Tree Day", or something related to Christmas or the Carnival.

In spite of the fact that she considered the extracurricular projects to be important to the students, she preferred to invest in classroom work. She referred to this aspect at the beginning of this school year and in the middle term interview, but she modified her opinion a little in the final interview. The final interview (annex H), shows that Paula recognised that the computer engages the students in mathematics learning, but there is already a critical sense, as she said: "we have to see very well where it can have advantages, and where it does not, because we have other materials." When she was asked to build up the picture of the computer situation she said:

"I have to admit that to develop work in the club that is worthwhile, it is necessary to do a work project, it is tiring, but I'm thinking of investing in it next year. I'm thinking of challenging the students with a theme and studying it with them, since I have realised that when they are doing only unrelated activities they soon become bored, even with the computer. I have already thought of a theme: "the defence of the environment, ecology". I know very little about this theme, I will have to study this with the students. We are going to explore the topic, to programme the activities, and the computer will start to appear and take its place. The theme should interest the students."

From the point of view of her own professional improvement she said at the end of the programme: "This work has developed me a little, as I have had to imagine new things to work on with my pupils". Later on, during the second interview, when she was asked about her opinion regarding the possible change in her methods of teaching, she said:

"... I have changed the way I teach, even my conception of what a lesson should be, and I believe that I have changed in a positive way" (first interview).

"I have completely changed. I was a little anxious about this work, but now I have seen that everything is going better than I could imagine. Students understand rational numbers better and operations with these numbers.... We have to alter the sequence of some content, the students work in groups, you know, the classes are noisier due to the enthusiasm of the pupils related to their work and their discoveries. I was very upset with the noise, but now I see myself also in the middle of that excitement" (second interview).

"...It makes me go out of routine. Usually I don't like to do the same things all the time,... the introduction of the computer was so great a transformation that I have had to re-think my way of teaching" (last interview).

Paula gave great importance to the work with her colleagues. She said:

"This work has enriched me, since it has made me meet with other people who are working on the same things as I am, exchanging experiences, discussing issues we have in common,... this was unfamiliar to me.... I think that with team work everybody gains something. There is no doubt that the computer is at the centre of all this. If the computer disappears I think that I will go on working with my colleagues, but within the classroom I do not know, ..."

In summary Paula considered that the computer as well as the support of her colleagues in preparing and discussing work in the classroom were fundamental to the change in her way of teaching. The trajectory of this teacher during these two years shows that, she was worried about the lack of students' engagement in mathematics learning, but after having worked in extracurricular activities in the first year, she believed that the computer would change this. After having worked within the classroom, she noted that the computer as well as other materials should be a useful resource, but that students need to become engaged in projects. It is interesting to see how, at the end of the second year, she wanted to give more importance to the project work.

Catarina

Catarina had fifteen years of experience as a mathematics teacher. She justified students' interest in computers since it was not related to the school work:

"...Yesterday if you could see, a very weak student when he finished doing a triangle with LOGO, he kept repeating: "this thing is amazing";...two days afterwards I set the same task but with ruler and protractor, and he still said: 'I can't do this!'. So I think that they like it because it is not related to class work, as the protractor and the rulers are. On the other hand they see that they are able to do nice clean things. When they did that work with computers to take to France in the 'Jeunes Europeans' programme, they felt very motivated because that work involved the trip, and they felt that they were different from the other pupils, and all that work was their work to show to the French students" (first interview).

She thought that the main role of the computer in school was to develop students' creativity, and that curricular and extra-curricular activities are complementary tasks to be developed. This teacher developed very interesting work projects during the first year. She gave great importance to the aspect of the students doing "things with a beginning, a middle and an end" (her words), and felt that students did not feel motivated when they went to the computer to do things without a purpose. Also the aspect of the students showing their work to other people was referred to: "they can do things that they can show to other people at the school. Usually the school does not promote these kinds of things". Concerning the use of computers in mathematics learning she showed a certain critical sense in saying at the beginning of the second year:

"...In some subjects it is possible to use the computer, because if they are interested they are ready to understand better. I am also thinking of developing other activities as free projects, in the club in order to develop with them other kind of skills as well as creativity" (first interview).

During this school year, in spite of the fact she was thinking of developing free projects with the students in the club, she did not dedicate much time to this work and she carried on with her classroom work. In the classroom, students always worked in groups with diversified activities, that means with the computer and on the tables. Sometimes students called her to answer some difficulties; her response was to refer them to the question to think about or to go to the "aids" when it was a situation with the spreadsheet. Once a group of students said "we are not able to do this, it is very difficult". She went over, talked with them, gave them some help saying "let's go and see this". Ten minutes later the students were the first to finish the task, and they said :"but this is very easy". Catarina saw the results they got and saw a mistake in the table of the spreadsheet, she told them to discover where they had made the mistake.

When she used the LOGO to approach the Geometry, she did not use the worksheets (annex P.1, P.2, and P.3), as she did not like them. She told me that they were too structured, and she did not see the difference between using the computer and just using the worksheets in the usual way. She preferred to challenge the students to discover the procedures for obtaining the polygons. For instance the students drew some polygons which they had learnt and they developed more complex pictures based on those ones. She told me: "I had some doubt as to whether I should give them the polygons formally, or if I should allow them to discover them. I chose the latter situation. I am going to experiment this way, let's see if they learn something". The students were at different levels of attainment in the tasks, but she did not seem worried about this. Concerning the classroom environment she said:

"Perhaps a little disorder, but it is quite a different sort of noise. First of all I think that what is done inside the class is more their work than my work...Sometimes they are so fascinated that I call them and they do not hear me, but this is not important since they are always active, because they can try by themselves to go on...
As they have greater participation in school activities, I can transfer to them part of the programming of learning activities, that means the accomplishment of tasks is a student responsibility; I think I have another role which is to prepare and organise the activities, it is the students who do them. I have also to be concerned about the different stages of learning because they have different paces of learning" (second interview).

Concerning Catarina's opinion about her improvement as a teacher, she became aware that usually she felt the need to control the students work:

"Do you know? I was persuaded that I didn't centralise the classroom work, but perhaps I did. It made me see things which I never had thought before. I believe that without the computer work I would not have been able to modify my behaviour in some aspects that I had never thought about before. I understand now that children go far on their own, and I never imagined that might be possible. Now I try to be quieter myself in the classroom, and with the computer this is easier than without the computer. The team work was also a very nice experience for me. The fact of children having a common project has a good influence on them". (first interview)

Later on during the second interview she said that the most important changes in her teaching methods were to let the students have greater participation in the development of the classroom and also to work in a team work: "I had thought that I would go crazy with the children doing different things at the same time, but it is simple".

The trajectory of Catarina during these two years seemed to be: extensive work in the project work in the first year, to carrying on in classroom work during the second year, but thinking that both were very important to student development. Her improvement as a teacher, according to her opinion was the promotion of student's autonomy, and creativity, and to achieve these she changed their way of working in the classroom using team work, diversified activities, and problem solving situations.

Ana

Ana had thirteen years as mathematics teacher. She interpreted the interest of students towards the computer as thought it was a novelty and as "they like to do and imagine things". She also expressed the opinion that children think that knowing about computers can be useful for their future lives. She gave importance to the involvement of other teachers in school in some projects using computers:

> "Those teachers who have begun working with our help, have become enthusiastic and some of them are trying also to experiment in their subjects... In project of "the problems of traffic" some teachers were engaged in little tasks, so I believe that should be possible to achieve some interdisciplinarity" (first interview).

Concerning students' gains in working with computers she considered, at the end of the first year, that the development of students' reasoning and the increase of self-confidence were the most important. She said: "...This makes them to believe in their ability and this is an important aspect of school success". Later on, after six months of classroom work during the second interview, she referred to the team work and the engagement of the students in mathematics activities. At the end of the second year she stated that:

> "They like working on computers and they finish by liking mathematics as well... They ask me 'when are we going to have computers', and they don't ask ' when are we going to have mathematics?"

In the classroom Ana chose firstly to work with LOGO approaching the rational numbers. The kind of activities which were designed for the students were closed (they should give the turtle the specific commands in order to paint a fraction of a given unity, see annexes R.1, R.2). She also used LOGO to develop some geometric concepts, as is displayed in annexes P.1, P.2, and P.2) . The students were working in groups, and there were two kind of activities: those working with the computer and those working with worksheets on the table. She had a very good relationship with the students, who were always calling her. When students put questions to her, usually she told them to think about it, or to discuss it with their peers. She also asked the students questions, mainly when they were working without computers. These questions were related to the work that they had been developing with the computer and were about mathematics content. As she told me: "Through their interest in computers they learn mathematics, they are so engaged ...".

Concerning the diversified activities, Ana would have preferred that students should work on the same activity if she could have had a sufficient number of computers, as she stated:

"...It was very hard to work like this, since a teacher alone cannot manage a classroom with students doing different things at the same time".

In the last interview she also expressed the opinion that the students "are too young and the teacher should conduct their work at the beginning, and little by little extend the student participation", because she believed that students "should participate actively since they are creative people".

Ana evaluated the programme related to her professional development, saying that:

> "I didn't know anything about computers, and everything was new for me... now I can change the sequence of the mathematics content, in order to maximise the potentialities of computers".

She valued the work with their colleagues, which was a support to her work:

> "... Together we prepare the materials for the students, this has been a very good experience,... the relationships among people are very important to me, and indeed I found a very good ambiance, even with the teachers of the other schools involved in this project".

She also reported her awareness about the importance of the engagement of the students in school activities to their success in the learning process.

In the middle term interview she mentioned that the most important thing was to experiment with new things with the students:

"...You know, I was used to having a set routine, I always did the same things every year, ...now I had the opportunity of experimenting with other materials."

In summary Ana seemed to be very enthusiastic about the computers as a way of making it possible to work with other people, involving teachers in her school in common projects. Also she was sensitive to the students' motivation towards mathematics, through computers. She liked to experiment with new things in classroom, but she did not agree with the students doing different activities in mathematics classroom.

Berta

Berta was one of the two teachers who was involved in the MINERVA project one year before the implementation of the teacher training programme of this study. As has already been said she worked at the same school with the other mathematics teacher who was invited in 1988/89 to belong to the advisory team of this Node of the project MINERVA. While the other teachers in the project were having their first experiences with computers she was already implementing, together with Dalia (her colleague), a project concerning the introduction of computers in a classroom setting. This experience consisted of developing two kinds of activities in the mathematics classroom: part of the class worked on problem solving, the other part developed LOGO activities. These last activities were open projects where students starting from geometric figures developed patterns, which were exhibited on the walls of the classroom. These teachers asked the school direction to join two hours of the mathematics schedule, in order to change the two groups of students, and so , all the students had the same activities for all the lessons.

Berta was a very experienced teacher with twenty five years experience as a mathematics teacher, and she was considered a good teacher but very traditional.

When she was asked about her opinion related to the interests of students in computers, she said that "they like everything that they can manipulate, and that gets them discovering new things". She added that:

> "... The passive role of the students is replaced by an attitude of discovery and greater mental activity, ... this fosters their self-criticism, and the possibility of the students discovering their mistakes and trying again" (first interview).

Berta also expressed the opinion that computers in school could foster interdisciplinary projects, but she was much more interested in curricular activities, so she did not develop any kind of extracurricular activities during this year, except some workshops about some software for their colleagues in the school. This disinterest in developing interdisciplinary projects was confirmed during the second year, since she used the club as an extension of the classroom. The students worked, during the second year mainly with the spreadsheet, and it was in the club that they learnt the technical aspects of this software. She preferred to separate the acquisition of technical knowledge from the formal activities concerning mathematics. However it is interesting to note that when she implemented "technical" activities with students she chose some tasks related to proportionality, as she mentioned:

> "They learn the spreadsheet without talking about proportionality, and in the next term, when I approach these concepts, they will already have the idea. They had worked with ratio and proportions without knowing what it is" (informal conversation, after a club observation).

Berta gave great importance to problem solving and she developed activities such as those displayed in annexes S1, S3, and S5. She chose problems to introduce mathematics topics, respecting the sequence established in the mathematics curriculum. Even the students that were not working with the computer were solving problems. She also used "to give lessons to teach the subjects" (her words), after the problem solving activities. In the second interview, two years and an half after beginning to work with computers with students she said that the main role of the computers in the learning process was:

> "...they are learning when they need to, they build their own learning... Computers engage them in thinking and in finding their own mistakes".

In the last interview she reported that:

> "...This also develops their concentration and reasoning, looking for problem solving solutions and for different ways of solving a problem. They can criticise the solutions they have found and this is very important indeed".

Concerning their professional development her colleague Dalia, who had known her for many years, said once that "you cannot imagine the difference that in Berta. She used to be so traditional in approaching mathematics with the students, she always explained to the whole class, she seldom used the problem solving..." Berta recognised some change in her teaching style, as she told:

> "...Now I feel more confident in the classroom and I have come to a new position, since I foster independent work by students, and I assume that they are able to overcome alone a great part of the difficulties" (first interview).
>
> "I dedicate more attention to problem solving.... The team work has raised issues of how to organise the groups, and I need to think about a lot of pedagogical issues" (second interview).

She also emphasised the importance of the collaboration with Dalia during the first year of work in classroom, as they prepared the lessons for the students together.

By the analysis of the work developed by this teacher and her opinions, it seemed clear that her confidence in mathematics teaching had increased, changing the activities that she developed with students, with more problem solving, her students becoming more independent in the learning process. The possibility of working together with other teachers was very important to her.

Carla

Carla had eighteen years of professional experience, eight of them being involved in in-service teacher training of mathematics teachers. When she was involved in the MINERVA project she had returned to the school one year previously just teaching mathematics.

Carla explained the students' interest in the work with the computer as being due to the fact that computers belonged to their epoch, and because it provided them with a more interesting image of the school, since "for most of them, school is boring", and she added:

> "... this gives them a certain freedom to make things. Normally the activities in classroom have teachers putting a pressure, and with the computer it doesn't' happen, since they are left to themselves, to the group, they don't feel so much the anxiety of the teacher and therefore they are more liberated to fulfil the activities according to their own pace" (first interview).

At the end of the first year, Carla was very interested in beginning work within the classroom, as she felt the need to change the way the mathematics classes were conducted. She expressed the importance of independent work and an active role for the students in the development of mathematics activities, saying that the computers could originate a change:

> "I want to see up to what point that is possible with our mathematics content,... It is natural that at the beginning it will be complicated, it will cause anxiety, but we must do it" (first interview).
>
> "It is a pedagogical resource and it has a specific role as a motivating instrument and a facilitator of school change, but the will for change has to be in peoples' heads (second interview).

Carla considered that in spite of the extracurricular activities being easier to implement, since "we don't have the pressure to accomplish the syllabus", the curricular ones are more important. The reasons pointed out were: "Students should like mathematics, and I believe in a living mathematics"; and she also said that:

> "...essentially the school is the classroom and therefore I don't agree with a school which has several enticing extracurricular activities, but the classroom continues being the same boredom as usual".

Later on at the end of this school year she stated that the role of computers out of the classroom should be viewed in two ways:

> "...One a resource centre and the other the computer club which it is not dependent on the class work. The resource centre would be that space where the students developed autonomous work, did their little researches, or used the computer as a tool to write in the word processor or to do graphics. The club as a space for autonomous projects must work with team work, developing amusing projects without being closed to only mathematics subjects."

Carla chose to approach the ratios, proportions and percentages using the spreadsheets which are subjects of the 6th level of mathematics curriculum. The annexes S1, S3, S4, and S5 are examples of the work that was developed with the spreadsheet within the classroom. She was working with the other five teachers who also chose to work with the spreadsheet, planning the classroom work and preparing the materials for the students. Carla was very enthusiastic about the spreadsheet since "it is possible to work on some mathematics subjects which students usually dislike and have some difficulties with", and because it provides the development of "problem solving activities" (informal conversation, 31/2/89). To develop this work with students she asked permission from the school direction to join two hours of the mathematics weekly schedule. The year before Carla had been developing activities with students in the computer club with LOGO, but during all this school year she preferred the spreadsheet. She stated that she would like to approach this software as it was closer to the mathematics contents, and to experiment with it in order to establish if it were possible to approach mathematics with the computer without the help of the extracurricular hours. She began to develop different activities at the same time in the classroom; one half of the class working with computers and the other half working on worksheets approaching the same subject. However four months later, in February, she decided to change this kind of classroom organisation and all the students were working on computers, being four to each computer. As she explained: "Students prefer to work like this, in the other way the students who were not working with computers became very noisy, because all of them wanted to go to the computers".

At the beginning of the class she always explained to the whole group of students what they should do and sometimes she asked to the students to stop work and listen to her. Then she explained some things related to their work. The students asked her to come and help them with some difficulties, but usually she told them to see in the "aids" (annex S2) or she asked them questions in order to clarify some aspects. For instance a student asked her "What does 10% mean ?", and she developed a conversation trying to get the student to understand by himself. Students introduced values in the table of the spreadsheet, trying to find a formula to solve all the situations of the problem that was to calculate several percentages of the same number. All the students were engaged in the work and during the break between the two hours just one or two students went out. In classes without computers (she chose to have two hours without computers and the other two with them), this teacher did a review of the contents approached with computers as she felt the need to "systematise the subjects, the computer breaks the subject hierarchy and for some students these is very confusing, they need the subjects set in order".

Carla considered that this new way of approaching mathematics with students, had some influence on her strategies within the classroom: "...I promote more independent student work and team work as well". She expressed the opinion that now she was aware that she had to think about student assessment, since "the traditional way of assessing by tests is not possible now". One of the aspects referred to more often by Carla was the possibility of developing problem solving with students, as for instance when she told me at the end of the first year of the study:

> "...Now it comes clear in my mind that problem solving is fundamental to the students learning of mathematics; all the independent work in which the computer is used as a tool, like anything else, where the children, or the group have to organise the work in their own way, and the contents are studied through the problem to be solved, I did not have that very clear in my mind and this work with computer has helped me to think about it" (first interview).

> "...I have to modify the students' assessment, but I need to work on it. I have promoted a little self assessment (second interview).

Concerning the importance of the teacher training attended in her professional development, Carla mentioned the group work as the most important thing:

> "...The exchange of experiences, the possibility of working with my colleagues, I am above all believer of group work in all human relations. It is by join reflection that things become gradually built up. And I think that reflection on pedagogical issues is very important, it is not only doing things together, it is fundamental to afford great reflection" (first interview).

She also considered that computer work with students, had helped her to clarify her role in school, since:

> "it has raised for me a lot of issues, for instance the problem solving versus the mathematical programme as we lost much more time doing problem solving...It is necessary to reflect deeply about this. For example it would be necessary to approach the rational numbers before the proportionality? This work during this year makes me think that perhaps it is not" (third interview).

At the end of the school year, when Carla was asked to build the picture of a mathematics classroom situation, imagining that she had no impediments of any kind, she expressed the following opinion:

> "If I had enough computers for everybody, I put them all working with the computer... For me it is very important to have some lessons without the computer to provide a systematisation of the subjects, for instance with proportionality, after work with the spreadsheet. Teaching with the spreadsheet, it is really important that students do problem solving, but it necessitates a great deal of thought, because the mathematics programme is very rigid and not interrelated. It is necessary to reflect deeply about this. For instance it would be necessary to approach the rational numbers before the proportionality? There are a lot of issues that I raise, and that would be good to be experimented on" (third interview).

This teacher showed a clear preference towards computers in the mathematics curriculum. As she always said this work motivated students towards school and mathematics, and fostered students' skills in the development of reasoning and problem solving. She felt the need to explain the mathematics topics after the work with computers, and she did it for the whole class. She had a awareness of the need to work in the organisation the mathematics programme in a way compatible with an approach using computer activities. To do this Carla preferred to work with her colleagues, and she referred several times to the importance of teachers meeting together and to reflecting on ways to improve the work in mathematics classroom. Concerning her professional development she seemed to be conscious that all this work provided a deeper understanding about some issues, such as student motivation towards mathematics learning, students mathematics assessment, and the importance of problem solving activities. Carla also showed the will to experiment in the future with new activities within the classroom and to reflect about them with her colleagues.

Dina

Dina had fourteen years of experience as mathematics teacher. She belonged to a school where there were five teachers involved in the MINERVA project, all of them working together since the beginning of the teacher training programme. Carla and Dina were the two mathematics teachers of this team. During the first interview, she expressed the opinion that students liked computers in school because they already played games with computers at home, but they did not get satisfaction from them, because they soon became bored, and because "they need to do things by themselves, to have their projects,... something that is meaningfully for them". This teacher's stance was that the main importance of computers in schools was to increase the students motivation towards the learning, as she said: "perhaps computers can modify their motivation to learn mathematics", and because:

> "...with the computer they need to touch and to do the things and with overhead projector they only need to see" (first interview).

During all this year Dina never wanted to work with computers within the classroom. She felt insecure, always saying that she needed more time to work in informal situations, and that she was waiting for the results of her colleagues. Nevertheless she always worked with the other seven teachers preparing the materials and discussing the strategies of the computer activities with students in classroom contexts.

> "At this moment, I think that I am not able to bring the computer inside the classroom, because I have a syllabus, some subjects to fulfil, and it is important to do it. So if the computer comes to disturb in some way the accomplishment of this, I don't agree. I feel the necessity of working for another year in the computer club, and then perhaps with more experience I can begin with curricular activities, but I have my doubts, since each person has her own way of working, her techniques; we may change something but the fundamental remains....I am more interested in working in the club, as I feel more responsible, but I am interested in seeing the results of some of my colleagues, who are going to begin with curricular activities, and then decide if it is worthwhile to change" (first interview).

Dina always mentioned the difficulties in accomplishing the mathematics syllabus if she was using computers. She felt a sort of feeling of professional duty to finish all the subjects of the mathematics programme, recognising however that children learnt the geometry with LOGO. This part of the middle term interview illustrates this:

> "...I recognise that children understand the geometrical concepts much better with LOGO as for instance the notion of angle, the polygons and the notion of variable. They get the meaning of these notions. But in mathematics class I have no available time to work with the computer, students need to go to the next school year knowing the contents of this year (second interview).

In the computer club Dina developed activities with students, using LOGO. These activities were integrated in the project "Interplanetary Trip: a trip though the time machine," chosen to be developed during this school year by some teachers of the MINERVA linked to the node of the Higher School of Education of Lisbon. This project began with students reading a book with the same name as the project, they discussed it with their teachers and they chose to develop some parts of the project. Dina's students chose the solar system. This work was developed using LOGOWRITER (that combines LOGO and word processing). The teacher used it to benefit the study of geometry. The students were working on different activities: two groups were in charge of writing a story related to the theme, one of these stories was "the planet of the mathematics people" and they were supposed to write in LOGOWRITER a story about this planet that should be illustrated with drawings. Others chose to draw the solar system, another decided to draw a butterfly. The annex O describes my observation of one of the computer club sessions, in May, with Dina and her students. The work environment showed that students were at their ease, sometimes students got up and they came see each other work. Most of them were engaged on their activities. The teacher collaborated in the students' discussion without imposing her opinion. She was not asked for help too much, and she was not worried about the maintenance of discipline. When during an informal conversation she was asked by me about one student who was not working, she seemed very worried about this student and another one who were both very weak and so they could not follow the work developed by their colleagues, and she added:

> "They have capacities to go further, I saw it in the club, but in mathematics tests they are a disaster. When I sat by them in computer club I saw that they were understanding and sometimes they write the right procedures in LOGO, they are making progress. They are very shy and are not confident in themselves. I am going to see their tests again and to see what I can do, I would not like them they to fail this year in mathematics" (May, 1989).

Dina in the last interview showed an interest in using computers within the classroom:

> "...I had an experience in the club that makes me think, after all they have learnt a lot of geometry; I am thinking about introducing next year computers activities in the classroom using LOGO; what is hard for me are the diversified activities. How can I manage the classroom space with both activities? Also in the club it is different, as the students worked projects, and the things on they learnt came from the need they had to accomplish them....To teach mathematics should have a sequence of activities" (third interview).

Dina didn't consider that she had changed very much during the first year of the programme:

> "I don't feel completely the same, but I cannot say that I have changed very much. I feel I need to know, to put all these things I have learnt into action, and I can use them better, that means, I have little practice. I feel the necessity to stop, to reflect, to try new things" (first interview).

When Dina was asked to speak about her methods of working with students in mathematics classes, after one year and a half of being involved with computers, she answered:

> "I don't know. Perhaps I have another perspective on things but I don't see a great alteration. In the classroom I work in a rank of two students at each table, but it is not group work. In the club it is different. They have their projects and I guide them" (second interview).

> "Within the mathematics class I am more rigid, I do not leave them so much at their ease.... I feel that the team work starts a lot of conflicts among children, you saw that girl who has a strong leader spirit, she always wants to impose her will on her fellows. Inside a classroom these things should not happen" (informal conversation, March).

> "I think I have changed a little, not much; now I am thinking of structuring my classes in a different way" (third interview).

This teacher expressed the need to work with her colleagues in order to begin work within the classroom:

> "I have great need of support and to exchange experiences and materials with my colleagues" (third interview).

This teacher seemed to reveal a separation of her role as mathematics teacher and her role as a guide to the students in the development of their projects, at least at the beginning of this second year. However she never expressed anything to show that the work which she was doing in the computer club was not also important. On the contrary she always mentioned the need for students to be engaged in doing things, and the way in which she involved her students was very decentralised, that means, she also asked for students' opinions and she gave them freedom to try and correct the things they did. When she spoke about her work within the mathematics classroom, it seemed to me that she was speaking about someone else. When at the end of this year, she mentioned the intention of taking computers inside the classroom, I was waiting to see. In the following year Dina began to work within the mathematics classroom with LOGO, and she is still continuing to do this.

Susana

This teacher had a long experience as a mathematics teacher (twenty eight years), having had two years working in teacher training. Susana considered that students were very motivated towards computers as "it is different work and it is a technology from their epoch". She also took the point of view that the introduction of computers into education was very positive:

> "... they try to do something and if they cannot, I tell them to try again, so I guess that this pushes them to think about and to feel that things do not happen by chance.... The computer engage them more than problem solving" (first interview).

During the second year of this study Susana attended the seminars with her colleagues of MINERVA, where they organised and prepared the classroom work, however she never decided to work with students inside the classroom. She was the leader of the more structured worksheets (annex R1 and R2). As this teacher had a great status, being the oldest and being known as a good teacher, she found agreement from these other teachers who preferred to adapt the activities with computers to be similar to the traditional work that they usually developed in mathematics classrooms. During the year before, Susana experimented with a piece of software to solve numerical expressions, which she obtained by herself. The objective was to verify if what children did at the table was coincident to the results that were displayed by the computer. A few times she took her students to the computer club, in order to practice this part of the mathematics syllabus. She remembered this experience as a negative one since there were only three computers and she divided all the class between these three pieces of equipments, being 8/10 students in each set.

> "...I feel myself enabled to see if all the students really accomplished their tasks with computers, since it is very hard for a teacher with thirty pupils to handle all this work, what I could see with that experience of the last year, was the students running to the computers to check if the results of the exercises which they had solved with paper and pencil, and I lost control. At certain point I noticed that they did not need me anymore. There was great confusion and I lost control. They showed great enthusiasm towards computers, they became motivated and I can guess that the liking of mathematics can appear.... I have noticed a certain competition among children, because there is always someone who is better and they want to know as much as their colleagues, and this improves their knowledge, and this doesn't' happen when the computer

is out" (first interview).

Susana always complained about the lack of specific software to teach mathematics, and it was one of the reasons expressed for not working within the classroom, during this school year:

> "I would like to have enough computers, and worksheets to approach the mathematics content, and I would need software related to that contents. It is because I don't have that software that I haven't used computers within the classroom" (third interview).

During all that year Susana developed work with students in the computer club, using LOGO and a programme to draw (GEM Paint). Each group of two students chose an activity, such as drawing a house, a ship or what they wanted. She was very often called up on by the students, and she went to the groups trying to explain, but she often solved herself what the students did not know. With LOGO, students used variables to draw the geometric shapes needed, but they were told how to proceed, without discussion it with students. I did not observe Susana promoting any discussion among students, or asking them questions in order that students could overcome the difficulties they had. When the students finished their tasks, they began another one. All these individual activities were not integrated in some common project. Some students did not look very motivated, and sometimes they didn't go (the attendance to the club was not compulsory).

When Susana was asked about her opinion concerning the main importance of computers in education she answered "the development of reasoning", and she added:

"I think that computers have a special role in schools, but when the overhead projector appeared they affected people as now the computer does,... I don't know. However I think that it is more difficult to put computers away, since they have different potentialities. It depends on what the ministry of education and the MINERVA will able to give to teachers. We are tired of working and not being rewarded for our engagement and effort. I believe that people have fewer and fewer illusions" (first interview).

Concerning the effects of her involvement in MINERVA, on her professional improvement, Susana said:

"When I look back I recognise that I have learnt a lot about computers, but I feel that I need to learn much more. All this work touched me, because I do not like to stop, and I like to experiment with new things. If I had not had this opportunity I think that I was doing the same things and less aware of this new potentialities (first interview).

During the middle term interview, the teacher did not give a direct answer concerning this subject:

"... In mathematics classes I have to teach them mathematics. In the club it is very different as they have the opportunity to do what they want to do and I don't intervene. As you know I am not working within the classroom, and I believe that it is necessary to modify some strategies when we put computers in classrooms, because there are so few computers" (second interview).

"... all this work helped me not to stop, and to do other things" (third interview).

It seemed that this teacher was looking for some software specific to approaching mathematics in the way that she used to teach mathematics. Even the worksheets which she was developing in the mathematics seminars she did not use. Once she told me that she was tired, and that was difficult for her to manage the classes with so many students. The computer club with so few students (she never worked with more than 12 students), was an opportunity to work with fewer children, developing different work. Also it seemed that she had developed a model of teaching mathematics which was not compatible with the work that was suggested by most of her colleagues using LOGO and the spreadsheet as well as the scarcity of computers inside the classroom. In the computer club, in spite of referring to it in informal conversations, as the work project, perhaps she never realised the pedagogical importance of this kind of methodology. She was a very polite person, and as she felt that most of us were fond of the work project, she never told us that she didn't agree with it. Or perhaps she thought that the unrelated activities that students developed during the club was indeed work project. However at the end of this school year when she was asked to build a picture of an ideal computer club work she answered:

> "We are thinking about collaborating with the school on the celebration of some festivities as the "Day of the tree". Students will develop work with a picture, a design or a poem and they ask to the teacher of this subject to correct them and then they go to the computer to write or to draw. The intention is to do interdisciplinary work to dynamize the school and to involve more students and teachers. I need the collaboration of the other teachers in the school, because the students are easily engaged. The great problem is to engage the teachers" (third interview).

The same question related to the classroom work had the following answer:

"Well, I would like to have time to do this work and to think about it, or then the people who did them should explain to me what were their intentions when they did them and the objectives of the worksheets. To use materials done by other people is not good as we can alter the intentions of the people who do them.

This teacher is still linked to MINERVA, and she continues working just in club, sometimes collaborating in some school projects such as the "Day of the tree", or "the Christmas".

Joana

Joana had twelve years of experience as mathematics teacher. She interpreted the first manifestations of students' interest towards computers as being because they associated computers with games, "so they begin working as they were playing", but she continued explaining what she thought happened after the first year:

"...When they are working with LOGO, I think that they become more engaged, because they choose a project to do, and they pursue it till the end, they are challenged by the difficulties which they are finding, but they never give up, they want to finish it. With LOGO there are always new things to learn, so they discover a new thing, they do it and another thing appears, and they want to try, and so on. With the word processor and the drawing programme, they are not so persistent" (first interview).

For this teacher the main importance of computers in education was the fact that children "construct the things by themselves" and that "many times what they learn is not established in advance" (first interview). In the second interview she said that:

"... The intellectual formation that this work provides for children. They learn to work with a computer programme, the first time may be hard but when we change to other software they learn it faster, they don't need me anymore. I think that they become more independent.

She always seemed to be interested in using computers in mathematics classes, and the reason was that "the relationship between me and the students is different, it is not necessary to call for their attention, they are always ready to learn something" (first interview). Concerning the possible changes which would occurred within the classroom by its use, she told:

"As children have greater participation in school activities, I can transfer part of the work for them, that means, the accomplishment of activities is a student responsibility, I think I have another role, which is to prepare and organise the activities, it is the students who do them. I also have to be concerned about their different stages of learning because they have different paces of learning" (first interview)".

Concerning Joana's preference between classroom or club work, she considered during the first interview that both were important, "since students are always engaged". However at the end of the school year she said:

"I prefer the club, as it provides a deeper social contact and a very good relationship among students and between students and me. Students are there because they want to and not because they have to be as in the classroom. They are free to develop their project... The ideal was to finish with the classroom. But what is the classroom? The fifty minutes? I don't know if in the future it is possible to be over with classroom, but with this kind of work the barriers are already down...Let us suppose that they are going to study a mathematics subject, or to solve a problem...This could begin in the classroom and to be continued outside doing some research and come back to the classroom" (third interview).

Within the classroom, she decided to work with LOGO approaching rational numbers and operations with rational numbers (annexes R3, R4 and R5). The class was divided in two groups, one working with computers and the other one at the table working with the geoboard or solving some worksheets concerning the same topics. In the following lesson the students' positions were changed.

She used to begin the approaching of mathematical concepts with computer activities, and with open problem solving situations. Once when I had been observing a class of Joana, she told me that she was worried about the accomplishment of the contents of the programme. Later on she told me that she had decided to continue working with computers in spite of spending more time, because she recognised that students gained in terms of autonomy, and persistence when they were solving a problem. She never seemed to have the need to have available time to systematise the mathematical subjects, as she worked with computers during all the whole school year.

She was also working in the computer club with other students. They were working on the theme "the Portuguese discoveries by sea", as well as developing a project to be integrated in the common project "the interplanetary trip". Joana promoted discussions among the students, and this was one of the aspects to which she gave more importance:

> "When they are speaking and explaining what they have done, they are understanding better the things which they are doing" (informal conversation, May, 1989).

> "Now I promote the students discussion, perhaps because the situations they are solving are more problematic" (second interview).

Joana mentioned the effect of the teacher training programme in the following way:

> "I never thought before, in terms of school dynamization that so many people might be involved... I could verify that being in school may be different and that students may enjoy going to school. I think that everything surprise me. This work obliges a person to go constantly onwards, we cannot stop. Everyday there are new things, even an answer that a student give us. The exchange of experiences is always positive, it is discussing with other people, so that people are improving their work" (first interview).

When she was asked about what she had changed in her methods of working with students, she answered:

> "They are not very different. What is different is the work that the students do. Now this work has more value. I prepare mathematics activities that are more problematic, they need to think, to try and to discuss among themselves in order to solve the situations... Students always worked in the same activity, and now as you know I have students doing different things. I usually worked in groups, but now I promote the students discussion, perhaps because the activities are more problematic. And there is a different student engagement in mathematics activities... What I feel is that I am going to continually to improve my suggestions for students work" (second interview).

At the end of this school year during the last interview Joana stated that the most important aspect she had realised through the work developed with students in computers was the students' creativity, and how students were discovering by themselves:.

> "One of the most important aspects was to see how the students are creative. They demand more time to work, and I have to give them the time they need, I understand that they have different paces. It is amazing to see the diversity of situations that they could

> create. ...You know other things several times students say that they do not know something, for instance how to divide a hexagon into six equal parts, but they do it, they observe that the diameter is the double of the side, nobody told them that fact, but they are able to do it as by intuition. Sometimes the things come like that. They try, they try again, they discover so many things" (third interview).

Joana seemed to become aware of students potentialities which she was discovering during these two years of work. As she gave importance to students development rather than to emphasising knowledge acquisition she became increasingly freed from the sequence of the mathematics programme, and of its accomplishment.